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STUDIES IN MELODY

A Dissertation submitted to the Faculty of the Graduate School of Arts and Literature in Candidacy for the Degree of Doctor of Philosophy

DEPARTMENT OF PSYCHOLOGY

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PREFACE.

In the first portion of this monograph are presented the results of investigations made in the psychological laboratory of the University of Chicago during the years 1905-07. The experiments which form the basis of the remainder of the work were carried on during the year 1907-08 in the Harvard psychological laboratory.

To the directors of these two laboratories, Professor James Rowland Angell and Professor Hugo Münsterberg, the writer desires to express his gratitude for patient counsel and stimulating criticism. He wishes also to acknowledge his obligation to the fellow-students of experimental psychology, who, in the capacity of observers, made possible the prosecution of these studies.

To the investigations of Professor R. H. Stetson in the field of rhythm the writer owes the method of attack employed in studying the relationships of muscular movement to the melody experience; and the outline of a motor theory of melody with which the present study is brought to a close is obviously the outgrowth of suggestions from Professor Stetson's important publications. Indebtedness to Professor Max Meyer is likewise evident, and nowhere more plainly than in those passages which express disagreement with his views.

My controversy with Professor Meyer is in part made necessary because of what seems to me to be an equivocal use of the term 'tonal relationship' on his part; and lest a similar ambiguity creep in to vitiate the discussions of the following pages, I have taken pains in each instance to specify in which of its two common meanings the term "relationship" is used. Musicians speak of two tones as directly "related" when the ratios of their vibration-rates are so simple that one tone is found among the first five partials of the other, or, what amounts to the same thing, when the two tones belong to a major triad, the 'chord of nature.' The "feeling of relationship" is the

experience of coherence, of 'belonging-togetherness,' which characterizes the hearing of two successive tones of the sort described. The question as to what pairs of tones arouse this feeling of "relationship" must of course be answered not by an arbitrary definition but by reference to the facts of experience.

Now it is perfectly evident that this particular kind of tonal "relationship," arising out of certain acoustical properties of the sounds, is not the sole kind of relationship which may bind tones together in our experience. Two tones may come to be felt as related, in a way, merely because they have often been heard together. Moreover any two tones whatsoever, be their ratios simple or complex, are felt to be related to each other as higher and lower. Here the term relationship is used in its ordinary broad, untechnical sense.

Whenever, in the following pages, the terms "relationship" and "related" are employed in the technical sense, they are enclosed in quotation marks; and where these marks are not used, the reader is to understand that the broader, untechnical connotation is indicated.

What the musician designates as tone-color or timbre, I have called by the usual psychological terms, clang-color, or briefly, color.

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PART I.

THE MELODY PROBLEM.

§1. Neither musicians nor psychologists are agreed as to the meaning of the term melody. Divergent usage, leading to misunderstanding and dispute, has arisen because within the range of melody experience there exist several distinguishable mental phenomena, each of which has in turn been construed as the essential mark of a melody. Weinmann,[1] following Lipps,[2] says that a melody is a *unity*, a whole, no mere succession of tones. It is, further, an esthetic unity in which the constituent tonal elements are subordinated to a single dominating element, the tonic. This definition operates to limit the scope of his study to such melody phenomena as those exhibited in modern European diatonic music, since it *a priori* excludes the possibility of melodies which lack tonality.

The doctrine of Lipps and his followers that esthetic unity always involves the *subordination* of the separate elements of a manifold to a single chief element is opposed by Meyer[3]. In his view, the statement that a melody is a unity means merely that we experience *relationship* between the tones. Indeed Meyer defines melody in terms of relationship.[4] To say that two tones are related and to say that they form a melody is the same thing. Such a definition avoids a narrow conception of melody. The scope of the term becomes much contracted, however, by the technical meaning which Meyer attaches to the term relationship. The essence of melody consists, for Meyer, not in the experience of any kind of relationship whatever between the successive tones, but in the experience of a very

[1] Fritz Weinmann: "Zur Struktur der Melodie" *Zeits. f. Psychol.* 1904, *35*, 340.

[2] Th. Lipps: "Zur Theorie der Melodie," *Zeits. f. Psychol.* 1902, *27*, 237. See also his *Psychologische Studien*, 2te Aufl. 1905, 193 ff.

[3] M. Meyer. "Unscientific Methods in Musical Esthetics." *Jour. of Phil. Psy., and S. M.* 1904, *1*, 711.

[4] Elements of a Psychological Theory of Melody. *Psych. Rev*, 1900, *7*, 246.

special and limited kind of relationship, namely that to which the technical musical term "relationship" has come to be applied. This narrowing of the meaning of the term operates to exclude from the realm of melody those songs of primitive peoples in which vague and indefinite pitch intervals appear, as well as the so-called melodies of speech.

Can we assent to Meyer's contention against Weinmann that melodic unity means nothing more than relationship between the parts? The esthetic unity which characterizes a melody does indeed involve experience of relationship among the several tones; but this is not all. For example, it involves also the experience of completeness. If the feeling of completeness is destroyed, the 'unity' is shattered. Not merely tonal relationship, but 'form' is necessary to constitute the esthetic unity of a melody. Meyer's deed here is better than his word: for throughout his investigations he searches for something more than mere "relationship" in his melodies, namely, for an *organization* of relationships, a combination of related tones ordered in one way rather than another,—arranged, indeed, so that they generate not a mere consciousness that the elements are related, but a perception that they are so related as to form a complete structure, a whole.

There are then, three clearly distinguishable phenomena, each one of which has been put forward as the peculiar differentia of melody: (*a*) "relationship" between the constituent tones; (*b*) esthetic unity or wholeness, such as distinguishes a definite melodic phrase when contrasted with a mere fragment of melody, or which characterizes even more clearly a complete melody that is brought into comparison with any portion of itself; (*c*) tonality, or the dominance of the entire sequence by a single tone, the tonic. Weinmann's definition stresses the third of these phenomena: if there exists a song of some alien people in which the preponderance of one tone over the others fails to appear, such a song must be called by some other name than melody. Meyer at the opposite extreme, emphasizes only the phenomenon of "relationship." Wherever "relationship" between successive tones is felt, a melody exists, even though the succession be fragmentary and the hearer be left in suspense, unsatisfied.

For the purpose of the present exposition, it has seemed best in defining what shall be meant by a melody, to place emphasis upon the second of these three phenomena,—upon the esthetic unity, the wholeness, which characterizes the completed experience. This usage of the term is adopted with full realization that it is not wholly unobjectionable. After such a definition, how shall one speak of Wagner's 'endless melodies?' By what name shall one describe the effect when in a Brahms chorus, one of the middle voices for a few brief measures stands prominently forth only to be lost to the ear again in a maze of counterpoint? Is not this tonal group without distinguishable beginning or end a most delightful melody? It would certainly be called a melody if, with Meyer, we had chosen to make "relationship" the sole essential; but in the terminology we have chosen, it must be called a melodic fragment, and not, strictly, a melody.

The matter of prime importance is, of course, to realize that by whatever names they may be called, we are confronted with three different phenomena—"relationship," phrase- or period-unity, tonality—which, no matter how intimately they may prove to be bound up together, are nevertheless in introspection clearly distinguishable, and must not be confused.

§2. At the risk of incurring the charge of prolixity from readers who are most at home in this field, I shall venture to develop somewhat more fully what I mean by a melody, before attempting to formulate explicitly the melody problem.

Let the reader ask himself in what way his experience of a melody differs from his experience of a mere succession of musical sounds of varying pitch. Possibly he will reply that the group of sounds that he calls a melody is more pleasing. But this agreeableness he will admit is not the essential character. One may, for example, upon hearing a flageolet of obnoxious tone quality find the whole experience disagreeable and yet recognize that what he is hearing is a melody; or on the other hand one may take delight in a perfectly random series of sounds drawn from a beautifully voiced instrument. Something other than the pleasurable affective aspect of the

total experience must be present to differentiate the melody from the non-melodic succession of pitches.

Upon further comparison of the two kinds of experience the observer will notice that the sounds of the melody seem to belong together, to cohere, and to stand in such a relationship each to the others that the entire series is felt to be a unity. The tones of the non-melody, by contrast, are felt to be unrelated: they do not 'hang together' as it were. Or, even if one discovers that some of the tones of the non-melodic group exhibit a close connection with some of the others, the group as a whole is not a unity: it is felt to lack consistency or internal coherence, or continuity, or completeness.

An example will make more obvious this contrast between the melody and the non-melody. I played to a group of moderately musical observers the following simple succession of musical sounds: $c' \; e' \; g' \; e' \; f' \; d' \; c'$. The tempo was slow, the duration of the tones uniform. I then played a second series beginning on the same tone and ending on the same tone, and employing the same five degrees of pitch as the first but in a different order: $c' \; f' \; d' \; g' \; e' \; f' \; c'$. The hearers reported that in the first group the sounds seemed to follow each other naturally, coherently, and in a way, inevitably, and with the last sound the series seemed to come to a definite close. Each element articulated with the others and the group as a whole was felt to be a unity. In other words, it was judged to be a melody. But with the second series of tones the hearers failed to discover this naturalness or inevitableness about the order of the sounds. The pitch, they said, wandered rather incoherently and disconnectedly here and there. Moreover when the last sound was heard it failed to bring the feeling of completeness, of finality, which characterized the close of the former series. This second succession of tones was judged by these observers to be no melody.

§3. Our definition of a melody places stress upon the experience of unity; but it does not prejudge the question as to whether this necessitates the subordination of all the elements to one dominating 'monarch element.' Neither does it imply that the experience of definite "melodic relationships" (in the technical sense of the term) is the *sine qua non*. A melody we

shall define as *a succession of musical sounds which is felt to constitute an esthetic unity*, a unity toward the establishment of which the *pitch* relations of the successive tones contribute.[1]

The melody problem, then, is the problem of explaining how a series of discrete tonal stimuli can arouse this feeling of unity.

As a matter of fact any actual melody such as a gamin whistles on the street or a Pawnee Indian sings to the dawn, gains its unity, its coherence, its wholeness, through the combined operation of many factors. The factors of intensity and duration, for example, are coördinate with pitch in the determination of the total psychosis: tempo, rhythm, dynamic structure share in determining what the melody shall be. A brief analysis of these factors will bring into prominence the particular phases of the melody problem with which these studies are concerned.

§4 It is to be remembered that musical sounds can vary one from another in only four ways: in duration, intensity, clang-color (i. e., tone-quality or timbre) and pitch. But each of these four aspects or attributes of the constituent tones affects in a two-fold manner the nature of the melody. The total effect is what it is, partly because of the *relative* duration, intensity, pitch and color of the separate sounds employed, and partly because of the *actual* pitch, intensity, duration and color. The 'actual duration' factor, for instance, is the tempo. The relative duration of all the sounds remaining constant, the nature of the melody may be entirely altered merely by changing the speed, i. e., the actual duration of the sounds. A familiar melody played in an unusual tempo may be hardly recognizable, and if the change of time is carried beyond certain limits in either direction the melody is utterly destroyed,—it becomes a confusion of noises or a broken succession of sounds without significance or interest.

Similarly, the actual or 'absolute' pitch of a melody enters in to make it what it is. The low rumbling melody with which Grieg begins the "Dance of the Trolls" in the first Peer Gynt suite is almost a totally different thing when played in the twice-accented octave, instead of three octaves lower.

[1] Here and throughout the paper, whenever the technical connotation of the term "relationship" is indicated, the word is enclosed in double quotation marks.

The difference which the actual clang-color makes is of course at the basis of artistic orchestration of melodies and of organ-registration. When a theme given out by the oboe is repeated by the violins we say it is the same melody, and yet it is not wholly the same.

Fourthly, the dynamic factor, the actual loudness or softness of the melody as a whole, remains to be mentioned as one of the contributors to the nature of the melody.

§5. These four factors taken in their actual or 'absolute' aspects are, however, of very secondary significance as compared with these same factors operating within the melody itself to contrast and to bind together the separate tonal elements. With reference to the *relative* duration, pitch, etc., of the individual tones, it will be convenient to treat of (*i*) the relation of each tone to its immediate associates, and (*ii*) the relation of the tone to the whole melody. (*Cf.* accompanying outline).

ELEMENTS OF MELODIC STRUCTURE CLASSIFIED ACCORDING TO THE FACTORS OF

I. DURATION

a) Actual (*Tempo*)	*b*) Relative i. Measure pattern Rhythmical figuration ii. Accel., Rit., etc.

II. INTENSITY

a) Actual	*b*) Relative i. Accent, stress, etc. ii. Cresc., decresc., etc.

III. COLOR

a) Actual (*Orchestration*; *Registration*)	*b*) Relative i. ii.

IV. PITCH

a) Actual (*Absolute pitch*)	*b*) Relative i. Interval relationships ii. Tonality relationships

Relations of duration of the first sort are at the basis of the measure-form and rhythmical figures, while accelerando and

ritardando illustrate the relations to a more inclusive group. Rhythm is usually a result of the combination of intensity and duration relations, although this is not always the case. Thus a melody played on the organ or on a mechanical piano player lacks variations of intensity of the separate tones.

In the case of the loudness factor, the former type of relation determines the effects of accent, of stress; while the latter gives dynamic form to the whole group, the crescendo-decrescendo effects, etc.

The relative color of the separate tones has, in the enumeration of the factors of melodic structure, usually been neglected. But *a priori*, one would expect this attribute of tone-sensation, as well as the others, to be of significance; and *a posteriori*, color is found to be of vastly greater importance to melody than one might suppose who had never given the matter careful thought. The reason why this factor has been overlooked is that it usually remains constant throughout the melody. Its presence as a unifying factor first comes into evidence when an unwonted change of color enters and makes itself felt as a disturbing element: as when a singer is not skillful in passing from one register of the voice to another, or a clarinetist meets a similar difficulty in making the transition from the lower to the middle register of his instrument. The changes in color which are thus unwittingly or unavoidably introduced have their disintegrating effect, be it never so slight, upon the melody. Among violinists this is a well known fact, a commonplace. Even so slight a change of color as is involved in the passage from one string to another is recognized as of importance in artistic phrasing, and the resources of technical proficiency are sometimes taxed in the effort to meet the requirements which this principle imposes. Such a principle raises a prohibition against careless shifts of color, and at the same time offers a positive aid to artistic phrasing,—it enables the violinist to give to a group of tones a peculiar unity of its own not otherwise obtainable. Surely such a factor in the determination of melodic form as clang-color,—a factor which has a recognized place in musical practice,—does not deserve to be entirely neglected. A careful experimental study of the effects and of the possible extent of alterations of color within the melody is a psychological desideratum.

§6. All of the factors which have been discussed, the relative clang-color, loudness and duration of the sounds, have been shown to contribute to the structural unity of a melody. But not all of these taken together are sufficient to make a melody. The essential factor is still lacking, namely the pitch relations. A sequence of tones of the proper relative loudness and duration to constitute a vigorous rhythm would not be called a melody if the pitch of the tones were either uniform or random.

The pitch, too, of each tone bears certain relations to the group of tones as a whole. This makes possible such phenomena as tonality, of which it will be necessary to treat in due time. At present let us focus attention upon the relations which may exist between individual tones.

These relations between tone and tone are of several distinct types. That type which has received fullest treatment at the hands of the musical theorist is the one which has appropriated to itself as a technical term the word "relationship." Two consecutive tones were said by Helmholtz[1] to be "directly related" if they form a perfectly consonant interval, in which case one of the clearly perceptible upper partials of the first is identical with one of the second; while to be "indirectly related" the two tones must each stand in some such direct "relationship" to a common third tone. This theory of "relationship" was used by him to account for the melodic intervals of the diatonic scale. To account for the appearance of chromatic intervals, 'accidentals', in melodies, Helmholtz further recognized a "relationship by propinquity"; the 'accidental,' he said, is 'related' to its neighbor by the mere fact of nearness. The fundamentally important type of "relationship" was, however, of the other sort; and since it had a basis in the physical laws of vibrating bodies, it naturally was described in terms of ratios of vibration rates. Like the phenomenon of consonance with which it is closely allied, direct "relationship" seemed to be dependent upon the partial identity of overtones which exists among "related" tones.

What now is the psychological phenomenon of which these physical facts seem to be the origin? In what way does one's

[1] H. Helmholtz, *Sensations of Tone*, tr. by Ellis, 1895, 256 and 350.

experience of a pair of "related" tones differ from that of a pair of "unrelated" tones? The difference is easily felt, but difficult to put into words. I shall here merely quote some more or less descriptive phrases from the records of my observers. When two "related" tones are heard in succession they are felt to 'cohere', to 'belong together', to 'articulate', to 'form parts of a larger whole.' "Unrelated" tones do not so behave. Rather they are felt to 'fall apart', to 'be unrelated'; 'they do not seem to belong to the same melody.' Tones at an interval of a major third exhibit a strong melodic "relationship." If the interval is increased by a quarter of a tone the "relationship" disappears. This phenomenon of "relationship" is not to be confused with that of consonance. The dissonant major second, for instance, is an interval whose tones exhibit melodic "relationship." What the significant connection is which exists between melodic "relationship" and consonance will be pointed out later.

Another type of relation which exists between the successive tones of a melodic interval may be called the relation of pitch distance. As regards their pitch all tones range themselves in a one-dimensional series, as higher or lower; and the relative position of two tones in this series finds its conscious representative in this feeling of pitch distance. Thus, the tone g' is felt to be at a certain pitch distance from c'; while its distance from d' is felt to be not so great. It is at once perceived that one's consciousness of the distance-relation between two tones is clearly distinguishable from one's consciousness of their consonance or of their "relationship."

It will be found useful to distinguish 'definite' from what may be called 'indefinite' pitch relations. The former are characteristic of all melodies which employ the definite intervals of a fixed scale. Some kind of 'indefinite' pitch relation must be experienced by that peculiar type of unmusical person who has no exact sense for intervals, but who enjoys hearing himself sing, and who can sing simple melodies in perfect time, and with so much sense for pitch relations as is shown in ascending when the melody should ascend, and then descending when the course of the melody takes a downward turn. The pitch-out-

line or melodic curve of his song corresponds in a vague, general way with the pitch-outline of the melody imitated, and in-so-far it betrays some kind of a sense for pitch relationship. These 'indefinite' pitch relations are characteristic of certain primitive melodies.[1] They also are of vast importance in the so-called melodies of speech. Indeed, the infinite variety of delicately expressive inflections which enrich our spoken intercourse must be recognized as based upon pitch relations of this 'indefinite' kind. The gross difference between the rising interrogative inflection and the falling assertatory is the most obvious example of this type of melodic relationship. The mental effects produced by mere rise in pitch have been described by Meyer in terms of effects upon the attention.

> A rise in pitch causes the hearer's attention to become strained, and the more so, the steeper the ascent, if I may use this expression. A fall in pitch, on the other hand, causes a relaxation of attention, a cessation of mental activity. . . . . The same strain and relaxation of attention is to be found in music. The normal end of a mental process is, of course, characterized not by strained, but by relaxed attention; for strained attention means continued mental activity. It is natural therefore that a melody ends with a falling inflection. . . . [2]

We shall have occasion frequently to refer to the significance for the melody problem of this "phenomenon of the falling inflection."

§7. If one carefully examines different melodic intervals to discover whether there may not be still other types of relation, he will probably disclose to himself a phenomenon which has received much attention at the hands of certain writers. He will notice that many melodic intervals exhibit a peculiar character which shows itself as a tendency for us to prefer one of the two tones as an end tone. The interval of the minor third, whose tones have the vibration ratio of 5:6, possesses no such attribute: one acquiesces indifferently in either the upper or the lower as a final tone. Neither tone has any very positive characteristics of finality about it. Not so, however, with the perfect fifth (2:3). If one hears it as an ascending interval, he is dissatis-

[1] *Cf.*, B. I. Gilman, "Hopi Songs," Jour. of Am. Ethnol. and Archeol. 1908, *5*, 14 and 224.

[2] *Am. Jour. Psych.*, 1903, *14*, 456.

fied, uneasy, and under more or less tension until he hears the first tone over again. But if it is a descending fifth which he hears there is acquiescence, satisfaction, repose, and no desire to hear the first tone a second time. One may say that one of these tones stands to the other in the relationship of 'tonic', or end-tone. This aspect of musical intervals will be called by the present writer their *melodic trend.*

Observation of this phenomenon as it shows itself in intervals of relatively simple vibration ratio has led some theorists, notably Lipps and his followers, to attach great importance to the 2 ratio. They find, for example, that the trend of the fourth (3:4) is very decidedly toward its upper tone as a final tone; of the major third (4:5), toward the lower; while the minor third (5:6) exhibits no noticeable trend whatever. The trend of the major second (8:9) is toward the lower, and of the minor second (15:16) toward the higher tone. Among the wider intervals, where the reader may perhaps feel that the phenomenon is not always so distinctly and unambiguously manifest, it is nevertheless held that the minor sixth (5:8) and the minor seventh (9:16) trend upward and the major seventh (8:15) downward, while the major sixth (3:5) shows no trend toward either upper or lower tone.[1]

It will be seen that in the case of every one of these 'pure' intervals the trend is toward that tone whose rate is a pure power of 2; 2 always becomes the tonic. Where neither rate is a pure power of 2, no trend is discovered. These phenomena have been grouped by Lipps under what he calls the 'law of the number 2.'

Kürzer gesagt:—Treffen Töne zusammen, die sich zueinander verhalten wie 2^n: 3, 5, 7 usw., so besteht eine natürliche Tendenz der letzteren zu den ersteren hin; es besteht eine Tendenz der inneren Bewegung, in den ersteren zur Ruhe zu kommen. Jene "suchen" diese als ihre natürliche Basis, als ihren natürlichen Schwerpunkt, als ihr natürliches Gravitationszentrum.

Dies ist naturgemäss um so mehr der Fall, je kleiner das (n) ist.

[1] These statements of typical trends are not completely in harmony with the results of the experiments described below. Differences are most in evidence in the case of the major and minor sevenths. See p. 25 *ff.*

(n) ist aber am kleinsten, wenn es gleich o ist. Und 2^0 ist gleich 1. D. h. die vollkommenste Ruhelage und das letzte Gravitationszentrum solcher Töne bleibt immer der absolute Grundrhythmus.[1]

Upon this law of the compelling, dominating character of the 2 ratio, together with the principle that melodic "relationship" is closer the simpler the ratios, Lipps grounds his theory that a melody is a structure which gains its esthetic unity through the subordination of all its elements to one over-mastering ground-ratio, the tonic. This theory has been elaborated, in its application to modern European music, in admirable detail by Weinmann,[2] and defended vigorously by the author himself.[3]

In undertaking to explain *why* this phenomenon of melodic trend toward the power of 2 should manifest itself, Lipps makes one fundamental assumption, the assumption

that to the rhythm of the physical vibrations which generate a tone there corresponds an analogous rhythm in the accompanying processes of tone-sensation, or in the accompanying change of psychic or central conditions; that thus the psychic or central process of tone sensation is separated into a succession of elements or elementary partial processes analogous to the succession of physical partial processes, *i. e.*, to the single sound waves.[4]

Such a correspondence between the nature of central processes and the physical processes which arouse them, Lipps has found it necessary to postulate not merely in the realm of audition, but throughout the range of sensory experience. Esthetic pleasure results from inner harmony of our mental (or central) energies. A color-contrast is beautiful if there is a subconscious apprehension of the simplicity of the combination of the ether vibrations.

In the present state of total ignorance with reference to the intimate nature of central processes no attempt can be made

[1] Lipps. *Psychologische Studien*, 2 Aufl., 1905, 195. An identical formulation is given in his *Grundlegung der Aesthetik*, 1903, 465.

[2] F. Weinmann, "Zur Structur der Melodie. *Zeits. f. Psychol.*, 1904, *35*, 340-379 and 401-453.

[3] *Cf.*, especially, *Psychologische Studien*, 193 *ff.*

[4] *Zeits. f. Psychol.*, 1902, *27*, 228.

either to establish or to disprove such an assumption. By those who cannot follow Lipps in his bold hypothesis, his theory of the number 2 must be viewed merely as a description, not an explanation, of the facts.

Weinmann undertakes to buttress this theory of the basic nature of 'duality' in vibration-ratios by reminding the reader that 'double rhythm' is the original rhythm, the simplest, the most natural, etc.[1] But this is an argument from sheer analogy; for the experience of *rhythm* in the ordinary sense of the word has nothing whatever in common with the unperceived micro-rhythm of Lipps' assumption. One is a phenomenon open to introspection, observation and experimental study: the other is hidden, unknown, hypothetical.

Even though one may not relish such a theory as that of Lipps and Weinmann, and though one may be inclined to doubt the adequacy of their formulation of the facts by means of the law of the number 2, nevertheless the phenomena of melodic trend remain and must be reckoned with. Why is it that some melodic intervals seem to end better on the upper tone and others on the lower, while with still others it is a matter of indifference which of the two tones comes last? Why is a rising fourth more 'complete' than a rising fifth? Why does an ascending major second create a demand to hear the first tone over again, while an ascending minor second does not?

§8. No further attempt will here be made to enumerate with greater completeness the various mental phenomena which flow from the facts of pitch relationship. Only those have been mentioned which are of especial significance for these studies: pitch distance, definite melodic "relationship," indefinite pitch relations, consonance, melodic trend, the phenomenon of the falling inflection. We shall later have occasion to ask which of these phenomena are primary and which secondary or derived.

Our survey of the factors—of pitch, duration, clang-color and intensity relations—which contribute to the structure of a melody, makes possible a more definite formulation of the limited purpose of these studies.

[1] *Op. c.*, 342.

How the *pitch* relations of a series of discrete musical sounds may operate to weld these sounds into the organic whole which we perceive as a melody,—this is the core of the melody problem, and to this primary phase of the subject our present investigation will be strictly limited. To this end we shall consider pitch alone, and abstract as far as possible from all considerations of rhythmic figuration, accent, force, tempo, tone quality, etc., although these various factors would all demand attention in any account of the melody problem which aimed at completeness.

PART II.

THE PHENOMENA OF MELODIC "RELATIONSHIP" AND OF MELODIC TREND.

§9. The reports of previous experimentation specifically directed toward the melody problem are few in number.

One of the most original and suggestive workers has been Professor Meyer, and a survey of his contributions will serve to bring our own problem more clearly to view.

The first of Meyer's experimental investigations[1] led him to reject the theory of the diatonic scale, and to develop a new theory of melody. He used a reed organ specially constructed so that in playing a melody the performer was enabled, for each note of the printed score, to select any one of two or three tones of nearly the same pitch. Thus after repeated trials he could determine precisely what intonation of any particular melody was most satisfactory.[2]

Meyer published his analysis of some thirteen melodies, giving the intonation of each which seemed to him to be the best. These include melodies of folk songs and chorals as well as melodies from well known classical compositions. The reader is not surprised to find that the preferred intonation does not coincide with that of "equal temperament;" but neither does Meyer find that the melodies are most satisfactory when played in the justly intoned diatonic scale familiar to musical theorists. To be sure, in the simpler melodies, most of the pitches in the preferred intonation correspond exactly with the pitches when the melody is played in accordance with the diatonic scale. Some marked exceptions appear, however. Meyer finds, for instance, that

[1] M. Meyer: "Elements of a Psychological Theory of Melody." *Psych. Rev.*, 1900, *7*, 241–273. Reprinted with revisions and additions in "Contributions to a Psychological Theory of Music," *Univ. of Missouri Studies*, 1901, *1*, 1–80.

[2] A description of the instrument, with diagram of arrangement of keys on the manual is found in the *Zeits. f. Psychol.* 1903, *33*, 292.

the 'fourth' is preferred flatter and the 'sixth' sharper than diatonic intonation demands. To render the nature of these differences more clear, reference may be made to the accompanying table.

TABLE NO 1.

	c	d	e	f	g	a	b	c
Ratios of pitches in diatonic scale	1	9/8	5/4	4/3	3/2	5/3	15/8	2
		9/8	10/9	16/15	9/8	10/9	9/8	16/15
	24	27	30	32	36	40	45	48
Some corresponding pitches from Meyer's Complete Scale.	1	9/8	5/4	**21/16**	3/2	**27/16**	15/8	2
		9/8	10/9	21/20	8/7	9/8	10/9	16/15
	16	18	20	21	24	27	30	32
Diatonic scale	48	54	60	64	72	80	90	96
Meyer's	48	54	60	**63**	72	**81**	90	96

The first line of fractions shows the ratio between the vibration rate of each note of the diatonic scale and the vibration rate of the key note. Reducing these fractions to a common denominator, we obtain as the resulting numerators the numbers in the third row of the table. These are the numbers usually employed to express the relative pitch of the notes in the diatonic scale. (The ratio between the vibration rate of each note and that of the next note in the scale is given in the second line of fractions).

For comparison with these, I have selected from Meyer's 'Complete Scale' those notes which are used in the simpler melodies (see lines 4, 5 and 6 of the table).

It is to be noted, first, that the ratios in the diatonic scale involve no prime number but 2, 3, and 5, whereas the other scale employs the number 7 in its fourth. Thus, to tune *f* in the key of *c* one would not tune it a perfect fourth above *c*, but would tune it at an interval of an harmonic or sub-minor seventh (7:4) above the *g* below. Moreover the denominators of all eight ratios from the newer scale are pure powers of 2 whereas this is not the case with the fourth and sixth of the diatonic scale. The amount of difference in pitch which is involved is shown in the last two lines of the table where the ratios of the two scales are reduced to a common denominator for comparison.

To understand the significance which attaches to these differences, and other more marked differences in intonation which come to light in the more complex melodies, it is necessary to examine two "laws of melody" which, if one follows Meyer, lie at the basis of musical theory.

§10. The first of Meyer's laws of melody may be called the law of *melodic "relationship:"* Only tones which are "related," directly or indirectly, can belong to the same melody. The second, a law of melodic trend, is similar to Lipps' law of the number 2.

We will give Meyer's own formulation of what he means by the term "relationship."

> When we hear successively two tones, the vibration rates of which are to each other as 2:3, or briefly speaking, the tones 2 and 3, we notice something not describable, which I shall call the *relationship* of these tones. To understand what is meant hereby, the reader may listen to the successive tones 7 and 11 or 11 and 10, in which cases he will notice that the two tones have no relation at all to each other.[1]

It is a fundamental contention with Meyer,—a contention that will demand our critical scrutiny,—that this psychological quality called "relationship" attaches only to pairs of tones whose ratios are expressible in simple fractions involving no prime number above 7.

> That no relationship at all is to be observed with tones represented by the prime numbers 11, 13, 17, 19, etc., leads to the conclusion that only tones represented by the prime numbers 1, 2, 3, 5, 7, and their composites possess that psychological property.[2]

This leads to the theory of what Meyer names 'the complete scale.' Since none but related tones can belong to the same melody, and since "relationship" seems to exist only between tones represented by products of 2, 3, 5, and 7, the complete musical scale, or the series of all the tones which may occur in a single melody, is represented by the infinite series of all products of the powers of 2, 3, 5, and 7 (p. 249). The beginnings of such a scale, containing so many of these related products as were found

[1] Meyer: *Psych. Rev.*, 1900, 246.

[2] *Op. c.*, 247.

to be needed in the analysis of the melodies he studied, are given by Meyer in tabular form.

In maintaining that the 7 ratio exhibits the fundamental melodic qualities and must not be excluded from musical theory, Meyer takes sharp issue with traditional treatments of the subject. Lipps and his followers who have done more than anyone else to place the theory of melody on a basis of exact descriptive formulation find no need of ratios involving prime factors larger than 5. Other writers, as Helmholtz, Gurney and Stumpf have also been content with the theory of the diatonic scale, a scale whose ratios employ the numbers 2, 3, and 5, but not the number 7. Against these, Meyer brings the charge that they have been influenced primarily by considerations involving the phenomena of harmony, and have failed to point out what facts observable in *melody* justified them in excluding the number 7. The facts as he finds them are that such melodic intervals as the sub-minor seventh (4:7) the sub-minor fifth (5:7) the septimal second (7:8), etc., do possess the pyschological quality of "relationship;" and what is of more weight, he finds that melodies played in his so-called complete scale, which admits the 7 ratio, are preferred to the same melodies played according to the diatonic scale.

Meyer has been subjected to criticism for publishing his experiments and basing an elaborate theory upon them, when the judgments of preference recorded are apparently those of a single observer, namely, the author himself. Meyer admits the force of these criticisms, but insists that even so much of induction and carefully systematized observation as this report of his studies embodied, has more claim upon the attention of a scientific reader than all the great mass of writing upon musical theory which has no scientific, inductive basis whatever.

How does Meyer account for the phenomena of melodic "relationship?" How does he explain the fact that we feel the tones 2 and 3 to be "related" and the tones 11 and 10 "unrelated?" In contrast to Lipps he does not attempt to account for the facts. On the other hand he frankly admits that he is not offering an explanation of the melody phenomena: for this, as well as for an explanation of the facts of consonance we must

await further light upon the nature of neural activity and the action of the sense organs. All that Meyer is attempting, then, is to comprehensively *describe* the facts.

His first step toward this descriptive formulation has already been mentioned. As a result of his examination of the phenomenon of melodic "relationship" he decided that all cases of "relationship" are capable of being expressed in relatively simple fractions involving no prime factors except 2, 3, 5, and 7; and consequently the 'complete scale' is limited to tones expressed in these numbers and their compounds. The second step is the formulation of a law of melodic trend similar to, but not identical with, that of Lipps:

> When one of two related tones is a pure power of 2, we wish to have this tone at the end of our succession of related tones, our melody.[1]

Expanded to cover melodies of more than two tones, the law assumes the following form:

> No hearer is satisfied if after having heard once or more often the tonic 2 he does not find 2 finally at the end of the melody.[2]

In the elaboration of his theory Meyer utilizes two additional principles. One of these is that among "related" tones there exist different degrees of "relationship." The other principle is that of all those intervals which possess a certain "relationship" we have a decided preference for the smallest. The detailed development of the theory based upon these principles we shall not here undertake to summarize, but its foundations we must pause to examine more closely. It is obvious that there is need of conclusive evidence supporting the basic proposition upon which the theory is erected, the proposition that tones representable by the prime numbers up to and including 7 alone exhibit "relationship."

As evidence Meyer presents, as we have seen, two groups of facts, one derived from an examination of separate intervals and one from observation of the use in actual melodies of the 7 ratio. In both cases, as Wead[3] has pointed out in his penetrat-

[1] *University of Missouri Studies*, *1*, 9.

[2] *L. c.*, 24.

[3] C. K. Wead, *Psychological Review*, 1900, *7*, 400.

ing review of Meyer's work, the judgments recorded are apparently those of a single observer, and he a man of harmonic training. What indication is there that one who had never become familiar with anything comparable with our European harmonic musical system would experience these elementary "relationships?" "Nothing," says Wead, "can be more certain historically than that these relationships have been unrecognized by most of the men throughout the ages who have concerned themselves about music." One cannot avoid asking the question whether Meyer's deductions necessarily hold for hearers of melody other than those who, like himself, have long experienced the associations of modern European music.

A somewhat similar question arises regarding the effects of practice in detecting these melodic "relationships."

Meyer leads us to understand that only after long and careful observation did he decide that 5:7 and 7:8 exhibit "relationship." In another connection he proves[1] that "relationships" not detected at first come later to be felt, upon greater familiarity. This seems to place him in a dilemma. May it not be that the familiarity breeds the "relationship?"

It would not be rash to hazard that if Meyer had chanced to spend his early years in the Scottish Highlands it would never have occurred to him to exclude 11 while admitting 7 among the prime factors of his 'complete scale;' for in listening to the bagpipe he would have become accustomed to the interval 11:12,[2] would have learned to recognize it accurately, and to feel "relationship" between 11 and 12 as truly as between 15 and 16, or 7 and 8.

As long as the question remains unsettled regarding the inclusion or exclusion of 7, 11, or any other ratio in making up the list of elementary "relationships," a certain doubt will remain regarding the validity of Meyer's experiments on the intonation of actual melodies; for, in selecting the preferred pitches the observer's choice of alternatives for each note, it will be remembered, was limited to the two or three tones

[1] See below, p. 40.

[2] *Cf.*, A. J. Ellis: "On the Musical Scales of Various Nations," *Journal of the Society of Arts*, London, 1885, *33*, 499.

available from the scale constructed out of products of 2, 3, 5, and 7.

Instead of attempting here to settle this issue, let us ask some further questions with reference to Meyer's two main contentions. Is it true that only intervals the ratios of whose vibration rates are expressible in small prime numbers manifest the psychological quality of "relationship?" Is it a fact that of two "related" tones whose ratio can be thus expressed, the hearer always prefers as an end-tone that one which is a pure power of 2?

§11. First let us consider the fact of melodic "relationship."

The major third is an interval which exhibits the character of "relationship" very unambiguously. This is an interval whose tones have the vibration ratio of 4:5. Now, what is the effect when we listen to an interval just barely wider than this, say the interval 400:501? It so happens that this interval exhibits the "relationship" more clearly, if anything, than 4:5 did,[1] although it is so nearly the same interval that those without special training cannot tell the two apart. Suppose this interval to be made a trifle larger yet, so that it has the ratio 400:504. Do the tones suddenly lose their character of "relationship?" One would hardly expect them to do so. Precisely what does occur is, that as the width of the interval is gradually increased it begins to change somewhat in character; but it remains a major third,—not a satisfactory third to be sure, but nevertheless a third with the *characteristic "relational" attributes* of that interval,—until it reaches nearly to the middle of the zone which divides the major third from a perfect fourth.

The experimental evidence, if any is required, in support of these statements, is easily obtained. The procedure adopted by the writer was to determine the effect produced upon the feeling of "relationship" by gradual but supra-liminal variations in the size of a melodic interval. Between the *b* and *c′* of a harmonium six reeds were interpolated, giving seven intervals, each of a magnitude of about 16 cents (*i. e.*, hundredths of

[1] Stumpf and Meyer found that all of the consonant intervals larger than a minor third are preferred too large. C. Stumpf and M. Meyer, "Maassbestimungen über die Reinheit consonanter Intervalle." *Zeits. f. Psychol.*, 1898, *18*, 321.

an equally tempered semi-tone). Such an interval in this region of the scale means a difference in pitch of scarcely more than two vibrations. It was thus possible to play any desired diatonic interval and also any one of half a dozen intervals intermediate in magnitude between it and the next larger interval. Only the major third and the fourth were tested. The method was without knowledge. The twelve observers were already familiar with the phenomena of "relationship" and finality in two-tone combinations. They were ignorant of the nature and purpose of the experiment. The observer was asked whether or not the two tones played were "related," and if the response was in the affirmative the further question was put, regarding the completeness or incompleteness of the two-tone group.

It was found, with each of the twelve observers, that the characteristic feeling of "relationship" was nearly always still present when the interval had been increased (or diminished) 32 cents, (a third of an equally tempered semi-tone). The characteristic feeling for the upper or the lower as an end-tone also remained. An alteration, however, of 48 cents (roughly a quarter of a tone) destroyed the feeling of "relationship" in 74 per cent of the 96 judgments.

In general, when a pure interval is gradually modified its characteristic melodic qualities remain long after the interval has lost the characteristic qualities, *e. g.* of consonance, which it manifests when its two tones are heard simultaneously instead of in succession. This fact ought to be of weight for any theory of melody which lays emphasis upon the psychological quality of felt "relationship." Since the ratio 3:4 has no monopoly upon the characteristic "relational" qualities of the fourth, but is rather only a modal ratio about which cluster an immense number of larger and smaller ratios manifesting in some measure identically the same psychological qualities, the use, without qualification, of the symbol 3:4 to represent that particular kind of "relationship" is misleading.

What is true in this respect regarding the facts of "relationship" is of course equally true regarding the facts of finality or melodic trend.

It may be urged that we are here confronted simply with the

common characteristic of perception, the modification of sensory data by central processes so that these data may be apperceived to the nearest available norm. Such tests as the above then would merely measure the tendency of the listener to hear different nearly equal intervals as the same pure interval, and do not prove that the "relationship" of the fourth inheres in any other ratio than 3 : 4.

But such a view neglects the fact that when we are listening to an interval slightly larger than 3:4, we may recognize it as larger and still at the same time experience the feeling of "relationship" characteristic of the fourth. The "relationship," in other words, inheres not merely in the interval 3:4, but also in intervals recognizably larger or smaller than the justly intoned perfect fourth.

§12. We shall not, however, press this consideration. Instead we shall leave in abeyance the question regarding the range of applicability of the pure powers of 2 formula, and shall seek, in the results of the experiments now to be described, the answers to certain questions with reference to the melodic trend in intervals with the simplest arithmetical ratios,—the intervals in which we are led to expect that the phenomena will be most in evidence. Does experiment establish the proposition that when one of two related tones is a pure power of 2, we wish to have this tone at the end, and that when neither of the related tones is a pure power of 2, no preference is felt for either as an end-tone? What is the relative strength of the trend in different two-tone combinations? Do the simplest ratios exhibit it most definitely? Do all observers feel it alike?

The method of the experiment was to present two tones in succession, and ask, "Can you make this second tone a final tone? Does this melody end?"[1]

The following series of ratios was used: 2:3, 5:6, 3:5, 15:16, 45:64, 4:5, 9:16, 32:45, 8:9, 8:15, 5:8, 3:4. This series was given in the 'double fatigue order,' both ascending and descending. Ten of the twelve ratios are relatively simple. Two, the aug-

[1] At the time when these experiments were planned, the experimenter was using the term 'melody' in the sense in which Meyer uses it. When the word implies nothing except "relationship," it is entirely appropriate to speak of melodies of only two tones

mented fourth and diminished fifth (32:45 and 45:64), involve pure powers of 2 but are not simple, and were included for purposes of comparison. Heavy Koenig forks mounted on resonance boxes and actuated by a rubber mallet were used as the source of sound. Each tone was sounded for five seconds. The range of pitch was limited to the once and twice accented octaves, the lowest fork being the middle c' of 256 d. v. and the highest the g'' of 768 d. v. In arranging the series *care was taken that neither of the tones of any pair belonged to a tonality which might have been suggested by the interval preceding.*

Eight persons served as observers in this series. None of them would be classed as totally unmusical, and none of them are "musicians," yet they represent, between these extremes, a wide range of musical ability. All are familar with musical notation and sing or play some from note. With at least two of the observers, there is a lack of interest in music, their skill at the piano being a mechanical acquisition. Three of the observers confessed to an acquaintance with the elements of harmony and musical theory, but it was evident upon trial that their theoretical knowledge was not concrete enough to exert any influence upon their immediate judgments of musical intervals. It may be remarked here that throughout these and also the later experiments the observers gave unreasoned judgments, the introspective records on this point confirming the opinion of the writer based upon the manner of their replies. All the observers had had training in experimental psychology.

The accompanying table gives the affirmative, doubtful and negative judgments of each of the eight observers with respect to each of the melodic intervals used.

TABLE NO. 2

Two Tones Heard in Succession. "Is the second tone a final tone?"

INTERVAL	OBSERVERS	An.	Td.	Bl.	Wl.	Rn.	Dg.	Mc.	Yo.	TOTAL
Minor Second, Ascending (15:16)	Affirmative	2	1	2	3	4	2	1	2	17
	Doubtful	1	0	1	0	0	0	1	1	4
	Negative	1	3	1	1	0	2	2	1	11
Descending	Affirmative	1	0	0	0	0	2	1	0	4
	Doubtful	0	0	2	0	0	0	1	1	4
	Negative	3	4	2	4	4	2	2	3	24
Major Second, Ascending (8: 9)	Affirmative	1	0	2	0	1	0	2	0	6
	Doubtful	2	0	0	0	1	0	1	1	5
	Negative	1	4	2	4	2	4	1	3	21
Descending	Affirmative	2	2	2	3	2	3	2	4	20
	Doubtful	1	1	1	0	1	0	1	0	5
	Negative	1	1	1	1	1	1	1	0	7
Minor Third, Ascending (5:6)	Affirmative	2	0	2	0	1	0	2	0	7
	Doubtful	1	0	2	0	1	0	0	1	5
	Negative	1	4	0	4	2	4	2	3	20
Descending	Affirmative	3	0	2	1	0	1	1	2	10
	Doubtful	1	0	1	0	1	0	1	0	4
	Negative	0	4	1	3	3	3	2	2	18
Major Third, Ascending (4:5)	Affirmative	3	1	0	0	0	0	0	1	5
	Doubtful	0	1	3	0	0	0	1	2	7
	Negative	1	2	1	4	4	4	3	1	20
Descending	Affirmative	3	3	4	4	4	4	4	2	28
	Doubtful	1	1	0	0	0	0	0	1	3
	Negative	0	0	0	0	0	0	0	1	1
Perfect Fourth Ascending (3:4)	Affirmative	4	2	4	3	3	4	0	1	21
	Doubtful	0	1	0	1	1	0	1	2	6
	Negative	0	1	0	0	0	0	3	1	5
Descending	Affirmative	0	0	2	0	2	0	1	3	8
	Doubtful	1	2	2	2	1	1	2	0	11
	Negative	3	2	0	2	1	3	1	1	13
Augmented Fourth, Ascending (32:45)	Affirmative	0	2	2	1	1	0	0	2	8
	Doubtful	0	1	2	0	0	0	0	0	3
	Negative	4	1	0	3	3	4	4	2	21
Descending	Affirmative	0	0	2	0	0	1	2	1	6
	Doubtful	0	1	2	0	0	1	2	1	7
	Negative	4	3	0	4	4	2	0	2	19

Cont. of TABLE No. 2

INTERVAL	OBSERVERS	An.	Td.	Bl.	Wl.	Rn.	Dg.	Mc.	Yo.	TOTAL
Diminished Fifth, Ascending	Affirmative	0	1	1	0	0	0	1	0	3
	Doubtful	0	2	2	0	0	0	0	1	5
(45:64)	Negative	4	1	1	4	4	4	3	3	24
Descending	Affirmative	0	1	1	0	0	0	1	0	3
	Doubtful	0	1	2	0	1	0	1	0	5
	Negative	4	2	1	4	3	4	2	4	24
Perfect Fifth, Ascending	Affirmative	1	0	2	0	2	1	1	3	10
(2:3)	Doubtful	2	2	1	0	1	1	1	0	8
	Negative	1	2	1	4	1	2	2	1	14
Descending	Affirmative	4	4	4	4	4	1	1	4	26
	Doubtful	0	0	0	0	0	2	1	0	3
	Negative	0	0	0	0	0	1	2	0	3
Minor Sixth, Ascending	Affirmative	1	4	4	2	1	0	1	1	14
(5:8)	Doubtful	3	0	0	0	2	1	0	0	6
	Negative	0	0	0	2	1	3	3	3	12
Descending	Affirmative	0	3	2	0	1	0	0	2	8
	Doubtful	4	0	1	0	1	0	1	1	8
	Negative	0	1	1	4	2	4	3	1	16
Major Sixth, Ascending	Affirmative	1	2	3	2	1	1	1	0	11
(3:5)	Doubtful	1	0	0	1	2	0	1	0	5
	Negative	2	2	1	1	1	3	2	4	16
Descending	Affirmative	1	2	3	1	0	1	0	0	8
	Doubtful	2	0	1	1	3	0	2	0	9
	Negative	1	2	0	2	1	3	2	4	15
Minor Seventh, Ascending	Affirmative	0	1	3	0	0	0	1	2	7
	Doubtful	1	3	1	0	0	0	1	0	6
(9:16)	Negative	3	0	0	4	4	4	2	2	19
Descending	Affirmative	0	2	2	0	3	0	2	0	9
	Doubtful	2	0	2	0	0	0	1	0	5
	Negative	2	2	0	4	1	4	1	4	18
Major Seventh, Ascending	Affirmative	0	2	2	1	0	0	2	2	9
	Doubtful	1	1	2	2	0	0	1	0	7
(8:15)	Negative	3	1	0	1	4	4	1	2	16
Descending	Affirmative	1	0	2	2	1	0	2	0	8
	Doubtful	0	2	1	0	1	0	0	0	4
	Negative	3	2	1	2	2	4	2	4	20

§13. These results indicate that the descending major third (4:5) and the descending perfect fifth (2:3) exhibit more of the quality of finality than any of the other two-tone combinations. The one was judged definitely to end 28 times, and the other 26 times, out of a possible 32.

The other intervals showing more affirmative than negative judgments are the ascending perfect fourth (3:4) with 21 affirmative judgments; the descending major second (8:9) with 20; the ascending minor second (15:16) with 17; and the ascending minor sixth (5:8) with 14.

The diminished fifth (45:64)—both ascending and descending—and the descending minor second (15:16) each have the highest number of negative judgments—24. These are the intervals that most clearly lack finality. The ascending major second is next with 21 negative judgments, followed closely by the ascending and descending augmented fourth, minor third, minor seventh and major seventh, and the ascending major third. The percentage of negative judgments of the ascending perfect fifth and the descending perfect fourth is the smallest of any of the intervals judged not to end.

The ascending minor seventh (9:16) and the descending major seventh (8:15) are both judged to lack finality, contrary to the law of the number 2, although their inversions, the major and minor second, conform to the law. The ascending minor seventh has only 7 affirmative judgments as compared with 19 negative; and the descending major seventh has 8 affirmative and 20 negative judgments.

What is the reason for the large number of negative judgments on these larger intervals? One answer is, that the tones of these wider intervals sometimes failed to arouse any feeling of "relationship." "Those two tones do not belong in the same melody." "That second tone cannot be a final tone because it has no connection whatever with the first." "No! The tones aren't related." Such introspections were frequently given when the wider intervals were used. These not highly musical observers experienced a sufficiently strong and definite feeling of "relationship" in the case of such a small interval as 8:9, but found all "relationship" lacking in the inversion of that same interval, 9:16.

This means that in formulating the facts of *their* musical experience it would not be permissible to do as Meyer has done, and "omit the number 2 as a factor," or in other words to treat the trend and the "relationship" in any interval as identical with that of its inversion.

§14. Three-fourths of the 24 combinations are judged *not* to end more often than to end. The total number of judgments is distributed as follows:

		PER CENT
Affirmative	256	33
Doubtful	135	18
Negative	377	49

If we leave out of consideration the more complex intervals, the augmented fourth and the diminished fifth, the totals stand as follows:

		PER CENT
Affirmative	236	37
Doubtful	115	18
Negative	289	45

From these facts it would seem that in general it is somewhat harder to accept the second tone of a two-tone sequence as final than it is to judge it to be lacking in finality.

§15. Do the results of these experiments indicate that descending intervals as such tend to cause the feeling of finality? To answer this question the data of Table 2 may be redistributed so that the totals for ascending and descending intervals may be compared. Following are the totals for all the intervals represented by simple ratios involving a power of 2, then for the more complex intervals (augmented fourth and diminished fifth) and the intervals whose ratios though simple involve no power of 2, and finally for all twelve intervals combined.

Simple Ratios Involving a Power of 2:

	ASCENDING		DESCENDING	
	TOTAL	PER CENT	TOTAB	PER CENT
Affirmative	89	35	111	43
Doubtful	49	19	43	17
Negative	118	46	102	40

Complex Ratios, and Simple Ratios without a Power of 2:

	ASCENDING		DESCENDING	
	TOTAL	PER CENT	TOTAL	PER CENT
Affirmative..........	29	23	27	21
Doubtful............	18	14	25	20
Negative............	81	63	76	59

Totals for all Twelve Intervals:

	ASCENDING		DESCENDING	
	TOTAL	PER CENT	TOTAL	PER CENT
Affirmative..........	118	31	138	36
Doubtful............	67	17	68	18
Negative............	199	52	178	46

In each group, tones which are powers of 2 had the position of first tone exactly as many times as they had the position of final tone; consequently it will not be far wrong to assume that any effects due to the operation of the law of the powers of 2 are cancelled.

There is found, especially in the first of these three summaries, some preponderance in favor of the descending intervals as more definitely final and of the ascending intervals as lacking in finality.

This effect of the falling inflection has been made the object of experimental determination by Meyer.[1]

Three tones of a reed organ were played a few times in irregular succession, ending on one of them. Then they were played in a similar way, ending on another one; and lastly, ending on the third tone. This was repeated until each subject had made up his mind and written down which of these three endings was the most satisfactory to him. . . . .

Two classes of experiments must be distinguished: one in which there was no tonic effect among the three tones; and one in which there were tonic effects. In the former case the three tones were represented by the symbols 3, 5, and 7; in the latter, by 2, 3, and 9. [The tones *e*, *g*, and $7b^b$ stand in the ratio of 3:5:7; *c*, *g* and *d* would be represented in Meyer's symbolism by 2, 3, and 9.] . . . . The three tones of one experiment were always within a single octave. Each of the three tones, however, had an equal chance of exerting its influence, *i. e.*, of being the lowest of the three. (P. 458.)

Where there was no tonic effect, the lower tone, whichever

[1] *Amer. Jour. Psych.*, 1903, *14*, 456.

it happened to be, was preferred as an end tone, the totals being 5 choices for the higher, 8 for the middle, and 17, or 57 per cent of the total, for the lower tone. In the other series, one of the tones was a 'tonic.' When this tone was also the lowest tone it was preferred as the end-tone in 86 per cent of the judgments. When it was the middle tone it received 70 per cent of the choices; and when it was the upper tone only 7 per cent.

These are striking results and one wishes that these experiments had been carried farther. Brief as they are, however, they serve to emphasize that the effect of finality at the close of a melody may be due in part to the operation of other causes than the powers of 2 phenomenon.

It thus is obviously desirable, in discussing the meaning of our own results, to separate as far as this is possible the finality effect produced by the falling inflection from that which is due to the more definite pitch relations of the tones.

§16. We shall first bring together the totals for those simple intervals (Group S) whose ratios do not include a pure power of 2, *i. e.*, the minor third (5:6) and the major sixth (3:5). The second summary will include the complex intervals (Group C) involving powers of 2, *i. e.* the augmented fourth (32:45) and the diminished fifth (45:64). Then will come the eight remaining intervals, all expressible in simple ratios one of whose members is a pure power of 2. These latter it will be convenient to separate into those intervals in which the 2 tone is the higher (Group H), and those in which it is the lower (Group L).

Group S. Simple Ratios without a Power of 2:

INTERVAL	*5 : 6*	*3 : 5*	TOTAL	PER CENT
Ascending				
Affirmative	7	11	18	28
Doubtful	5	5	10	16
Negative	20	16	36	56
Descending				
Affirmative	10	8	18	28
Doubtful	4	9	13	20
Negative	18	15	33	52

Group C. Complex Ratios Involving a Power of 2:

INTERVAL	32 : 45	45 : 64	TOTAL	PER CENT
Ascending				
Affirmative	8	3	11	17
Doubtful	3	5	8	13
Negative	21	24	45	70
Descending				
Affirmative	6	3	9	14
Doubtful	7	5	12	19
Negative	19	24	43	67

Simple Ratios Involving a Power of 2:
Group H. (Higher tone a Power of 2.)

INTERVAL	15 : 16	3 : 4	5 : 8	9 : 16	TOTAL	PER CENT
Ascending						
Affirmative	17	21	14	7	59	46
Doubtful	4	6	6	6	22	17
Negative	11	5	12	19	47	37
Descending						
Affirmative	4	8	8	9	29	23
Doubtful	4	11	8	5	28	22
Negative	24	13	16	18	71	55

Group L. (Lower tone a Power of 2.)

INTERVAL	8 : 15	2 : 3	4 : 5	8 : 9	TOTAL	PER CENT
Ascending						
Affirmative	9	10	5	6	30	23
Doubtful	7	8	7	5	27	21
Negative	16	14	20	21	71	55
Descending						
Affirmative	8	26	28	20	82	64
Doubtful	4	3	3	5	15	12
Negative	20	3	1	7	31	24

According to the Lipps-Meyer formula, intervals of Group H should end better on the higher tone, and intervals of Group L on the lower. Consequently in Group H the finality effect due to the 2 ratio is opposed by the rising-inflection phenomenon, but in Group L the two forces work together.

Comparing the totals for all the intervals which according to the law of 2 should end, *i. e.*, the ascending intervals of Group H and the descending intervals of Group L, we find 59 affirmative and 47 negative judgments in the first case, as contrasted with 82 affirmative and 31 negative judgments when the effects of the two forces are cumulative. The

influence of the falling inflection increases the proportion of affirmative judgments very noticeably. Preference for the descending intervals as more definitely final does not, however, come to light in comparing the descending intervals of Group H with the ascending intervals of Group L—intervals which according to the Lipps-Meyer law lack finality. In both cases the negative judgments are more than double the affirmative in number, and the totals are almost exactly the same in the two groups.

It is instructive to combine the totals for the ascending intervals of Group H and the descending intervals of Group L, obtaining in this manner the totals for all judgments upon intervals which according to the formula of Lipps and Meyer ought to be judged to end. These may be compared with the judgments upon the same intervals played in the opposite direction, which according to this law are characterized by lack of finality:

End Tone a Power of 2:

	TOTAL	PER CENT
Affirmative	141	55
Doubtful	37	14
Negative	78	31

First Tone a Power of 2:

	TOTAL	PER CENT
Affirmative	59	23
Doubtful	55	22
Negative	142	55

§17. This last summary presents strong evidence of the operation of some such tendency as that to which the Lipps-Meyer law refers. When 2 is the end tone, the two-tone group is said by these observers to end in 55 per cent of the instances, and not to end in 31 per cent, the remaining 14 per cent being 'doubtful.' When 2 is the first tone of the pair, the proportions are reversed. Only 23 per cent are judged to end, while 55 per cent are judged to be lacking in finality.

In attempting to account for the judgments which do not conform to the law, it is to be remembered that in exactly one half of the instances in each group the effect of the rising

or falling inflection was acting in opposition to the phenomenon under discussion. Hence a certain ambiguity and uncertainty is sometimes inevitable. But the inadequacy of this explanation to account for all of the facts becomes manifest, when we examine afresh the separate data from which these totals are compiled (p. 25). Why does the same observer declare at one time that the ascending minor third, for instance, ends, while at another time he declares with no less positiveness that it does not end? The fact that some of the observers were but slightly musical accounts for part of these anomalies,[1] but some contradictory judgments occur in all the records including those of the most musical observers. How can the latter be explained?

The suggestion was made that the fork tones were so nearly pure that the feelings of "relationship" were weak and consequently the reactions produced were not normal. But the real difficulty did not consist in any *lack* of feelings of "relationship" and of finality, but rather in the fact that these feelings were apparently often *misplaced.* Moreover, control tests with harmonium and piano tones rich in upper partials failed to decrease the proportion of contradictory judgments.

§18. To gather further data another series was arranged containing, besides the twelve of the original series, five additional intervals: 24:25, 9:10, 27:32, 20:27 and 27:40. Five quite musical observers served, including the two most musical of those who had assisted in the previous experiment. The procedure was varied by putting the question differently: "Do you feel any desire to return to the first tone?"

With the attention thus directed, it is not surprising that some of the observers reported with certain intervals that they desired to hear the first tone again, whichever way the melodies were played, ascending or descending. Thus was forced into notice what has been called the *law of the Return,* the law that, *other things being equal, it is better to return to any*

[1] For example, when observer Bl. reported that an augmented fourth ended satisfactorily on the upper tone, he was asked to hum the interval upon which he had passed judgment, and sang a perfect fourth. The same thing occurred in the case of Td, who, however, discovered after he had sung the interval that it was not the same as the one he had originally heard, and wanted to change his judgment upon it.

starting point whatsoever than not to return—a simple, fundamental principle of musical form, of art form of any kind, indeed.

Another law to which the introspections pointed is not so simply formulated. It was brought to attention by three observers who persistently found an additional alternative in the case of certain intervals: the melody lacked finality, there was no desire to return, neither tone would serve as an end-tone but some *third* tone was demanded. Here was a melodic trend, definite, positive, insistent; a property of a single pair of successive tones, but leading beyond them to something further.[1]

It was plain that the facts of elementary melodic "relationship" and the law of finality of two-tone melodies did not tell the whole story. The phenomenon of melodic trend seemed to be of a more complex sort, even in two-tone groups, than is implied by any statement of a tendency to return or not to return. Even with these simple two-tone sequences it was necessary to recognize the operation of some such law as the following: *Two melodically "related" tones tend to establish a tonality*, and the melody is judged to end only when the final tone is one of the members of the tonic triad—preferably the tonic itself.

This law is not asserted to be a universal law. Indeed it is doubtless limited in its application to the experience of those reared in a harmonic musical atmosphere. In so far as it is found to be valid, it indicates the probability that the phenomena of melodic trend are not primary, but are derived from our experience of consonance.

These experiments were supplemented by briefer and less systematic tests upon a number of observers, unpracticed in psychological observation. The results were in general confirmatory, although not as strikingly uniform as those we have already given. Mention will be made only of four of the observers whose records are exceptional. Two of these exhibited a persistent preference for endings that suggested

[1] These introspections complicated the records so much that it is not deemed advisable to reproduce them here in full.

the minor mode. Tested upon the interval of the minor third (5:6)—no tonality having been previously supplied—these observers uniformly judged the ending on the lower tone, (5), to be satisfactory, while the ascending interval was judged to be lacking in finality. One of these observers is a very musical Welshman, and it is to be recalled that much of the characteristic Welsh music is in the minor or as they call it, the "la" mode. Tests were made upon two Japanese young men who had recently arrived in this country and who professed to have had but little opportunity to hear European music. Both were singers and one was a performer upon the Japanese flute. The tests, repeated, gave very conflicting results, and it became evident that either the interpreter had failed to make clear to them precisely what the phenomenon was upon which they were to pass judgment, or else their experience of melodic trends differs essentially from ours. Unfortunately it was not possible to carry out an extensive series of tests with these observers.

§19. For purposes of comparison, a third set of experiments was undertaken in which the tonality feeling was not left to be contributed by the hearer, but was definitely suggested to him. In the previous experiments, the utmost pains had been taken to exclude the operation of tonality by arranging that neither of the tones of a given group should belong to any tonality which might have been suggested by the immediately preceding experiment. If any tonality was present, it had a subjective origin. We have seen that many apparently contradictory judgments were given, as for instance when a minor second was judged to end, now on the higher and at another time on the lower tone, both judgments being positive and emphatic.

In the experiments now under discussion, on the other hand, the device was used of controlling the tonality, imposing it from without and testing after the judgment had been made to see whether or not the objectively given tonality had been retained. To facilitate this procedure, a piano tuned in equal temperament was used instead of the forks.

These experiments were carried out upon five musical observers, practiced in psychological observation. Three of these were quite naïve as to the nature or course of the experiment.

All the intervals of the tempered scale exclusive of the octave were employed. Each interval was used, beginning at every possible position in the scale: thus the ascending fourth was heard, beginning on 1, 2, 3, 5, 6 and 7 of the scale. The series was given in double fatigue order. The experimenter noted down the observer's introspections regarding the trend of the interval, or trends, for several optional directions of melodic movement were often detected. In these instances where more than one leading presented itself to the observer, an effort was made to determine the relative strength of each.

The result suggested by the previous experiments came clearly to view: so long as the given tonality was maintained, the trend of any interval, ascending or descending, was toward some member of the tonic chord, preferably the tonic itself. Individual differences showed themselves as stronger or weaker demands for the tonic as the end-tone, as over against the third or fifth when the latter were nearer than the tonic. For example, in the key of *c*, observer Rn felt that the sequence g' f' demanded c' as its third tone, whereas the other four observers found the trend to e' stronger. The uniform tendency for all five observers, however, with all the intervals, was to rest in one of the tones of the tonic chord.

Our contention is that in the previous experiments with no objectively supplied tonality, the anomalous results and contradictions above mentioned are explicable on the hypothesis that tonalities, now one and now another, arose in the mind of the observer. The minor second e'-f' would at one time chance to suggest the tonality of *f* and end satisfactorily on the upper of the two tones; while at another time the tonality of *c* would arise, entailing quite different demands.

§20. We have too long neglected to specify what is implied, psychologically, in the term tonality. By a tonality is meant a group of mutually related tones, organized about a

single tone, the tonic, as the center of relations. Subjectively a tonality is a set of expectations, a group of melodic possibilities within which the course of the successive tones must find its way, or suffer the penalty of not meeting these expectations or demands of the hearer and so of being rejected as no melody. Of these different demands, that for an end on a certain tone is the strongest and most characteristic.

It is not meant to imply that this tonality, this system of related pitches with a common center of reference, is present in consciousness as a group of auditory images. Often there is only a single simple auditory or vocal-motor image or percept to be detected. The tonality consists in the *attitude* of which the image is merely the superficial manifestation or sensory core. One can image the tone of 320 d.v. as a tonic in the key of *e* or as a median in the key of *c*, and the auditory image will be identical in the two cases, but not the total psychosis. There will be an entirely different organization of expectations, an entirely different attitude, an entirely different set of anticipations and demands, a preparedness for one set of experiences, but not for another.

So much an impartial introspection cannot fail to disclose. The position here advanced is that these same "attitudes" are constituted in large part of kinæsthetic elements—reports of processes of *motor adjustment.*

Suggestions toward such an interpretation of the tonality phenomenon were abundant enough from some of the observers. When Ha. felt a melodic trend unrealized, he often described it as a *vocal tension*, due to a tendency to sing the desired pitch. An. reported kinæsthetic sensations from the throat as accompanying the feeling of expectation. He also mentioned sensations of strain and tension in other regions, notably the diaphragm, these general tensions being especially prominent at the instant when he was attempting to retain an elusive tonality against an auditory distraction (as when, for instance, given the tonality of c, he was asked to listen to the interval c-f.) Do. found that "the effort to hold a tonality involves general organic tensions. Any lapse

of attention or shifting of muscular tensions precipitates a shift of tonality. Changes of breathing will do this,'' etc., etc.

Considerations such as these pointed toward the value of an approach to the problems of the melody experience from the side of its motor accompaniments, and resulted in the experiments reported in Part III upon the motor effects of simple melodic stimuli.

Whatever the nature of a tonality 'attitude,' whatever its relations to sensations of strain and muscular movement—it is at least a phenomenon which widely pervades the musical experience of hearers who are familiar with European music. The question now arises whether either the tonality experience or the experience of finality in two-tone sequences is primary, original, fundamental: Does the law of 2 describe a primitive, natural tendency or preference, which has operated in the course of historical development to mould our musical system, or does it describe certain secondary, derived phenomena which would not be discoverable in an experience wholly uninfluenced by association? Proofs of the former alternative the writer has been unable to discover. Moreover, the history of our musical system points toward a gradual evolutionary process in which the *primary phenomena of consonance* have been efficacious factors. Hearers whose minds have been influenced by association with such a musical system, when listening to certain two-tone sequences cannot avoid feeling a preference for one of the tones as an end-tone. Some of these preferences lend themselves to formulation in terms of the Lipps-Meyer law of the number 2; but this law is only a *special case* of the more general law that every melodic interval trends toward one of the tones of the tonic chord of the tonality which it arouses. The law is based upon the tendency of every interval, yes, of even a single musical sound, to establish a tonality attitude. The manner in which the law operates will be evident from one or two simple illustrations.

What shall be said, for instance, of those curious, sometimes baffling experiences, in which a second tone is at first

unwelcome, and then quickly makes itself at home and usurps the place of what had before been anticipated as the final tone? In certain instances nothing is more natural or inevitable. The first tone arouses a slight tonality feeling, making itself the tonic, so that if we call this tone *c*, we shall have an 'attitude' in which any of the tones *c*, *e*, and *g* of the tonic chord (but especially *c* itself), would be welcomed as possessing something of the quality of finality. Suppose now we hear the rising fourth *c-f*. When *f* first enters, as a final tone it is not welcomed: it does not meet the requirements of those expectations aroused by the first tone. But *c-f* is a harmonious interval: it immediately tends to shift the organization of the tonality feeling to something which will *include both c and f* in one common tonic chord. This is, of course, the chord *f-a-c-f′*, of which *f* is the fundamental. If this transition is successfully made,— and the chances are that such a transition can be avoided only with conscious effort,—then *f* becomes a final tone, and the interval which at first felt incomplete and unsatisfactory comes to a definite close.

Why does the descending fifth end while the rising fifth does not? When one hears a tone *c* and then its fifth, both fit without readjustment into the *c-e-g* tonality suggested by the first tone, and for complete finality one wishes to hear again the tonic *c*. But if, instead of ascending from the tone *c*, we hear a descending fifth from the same starting point the situation is altered. The chord which includes the original *c* and this new tone *F* is the chord *F-A-c*. Our demand is, accordingly, to hear as a final tone the tonic of this chord, which is *F*. A similar treatment applies to every instance of "direct relationship" in which the law of 2 was found to hold good. This law of the powers of 2 is no primitive universal law: the phenomenon it describes is peculiar to those minds habituated to a musical system whose scale has a basis in the laws of consonance and dissonance.

§21. The overshadowing rôle played by habit or association in the drama of our esthetic experience is not always recognized. The effect of habituation in rendering disagreeable

sequences tolerable or pleasant and in changing unrelated into related tones, has been shown by Emerson[1] and also by Meyer[2], although the latter finds in his results substantiation for a very different contention, namely, the universal applicability of the "complete scale."

Emerson worked with extremely small melodic intervals and found that after much experience with these small intervals his observers developed preferences for certain sequences, showing that a melody can be constructed of tones all of which are within the compass of a semi-tone.

Meyer constructed some 'quarter-tone melodies' from the intervals of his complete scale. At the initial performance, the effect was judged by most of his observers to be disagreeable, but on repetition this judgment was modified, and two weeks later, at still another hearing, some of them came to appreciate and enjoy the music which had before been strange and incomprehensible. What an excellent illustration of the law that we do not accept as melodically good that which we cannot in some measure anticipate!

Subjected to careful introspective analysis, the feeling of finality attaching to the second tone in the interval 3:4 differs in no essential from the feeling of finality attaching to the last tone of a purely arbitrary tone combination with which one has grown familiar. In each instance the sense of finality consists of the same kinaesthetic sensations in throat and diaphragm, the same feelings of relaxation, the same repose, the same slight retardation in the rate of mental flow.

This effect of habituation is a familiar fact in the musical experience of everyone. Tonal sequences at first bizarre, strange, unmusical, later come to be appreciated, understood and enjoyed. Some degree of habituation to any succession of intervals whatsoever makes possible the act of recognition, of acknowledgment, of 'welcoming' the successive tones, to use Professor Royce's apt phrase. Habituation, then, is

[1] L. E. Emerson, "The Feeling Value of Unmusical Tone Intervals," *Harvard Psychological Studies.* 1906, *2*, 269.

[2] M. Meyer, "Experimental Studies in the Psychology of Music," *Am. J. Psy.*, 1903, *14*, 456.

sometimes a powerful factor in making possible that active participation which seems to be demanded of the hearer before the succession of musical sounds can for him be unified into the organic whole we call a melody.

§22. *Summary.* These studies began with a definition of melody which laid stress upon the feeling of unity. When the separate tones of a series are felt to be related to each other in such a manner that each tone forms part of a coherent whole, the succession of tones, we said, is felt to be a melody, and the melody problem was stated to be the problem of explaining how this feeling of melodic unity arises. An analysis of the psychological elements of melodic structure revealed many and varied sources contributing to the generation of this unity. One group of factors, however, stood out as of unique importance, namely those due to the relative pitch of the constituent tones; and to the consideration of problems in pitch relationships the scope of the present investigation was limited.

A survey of the efforts that have been made to reduce the facts of melodic "relationship" and of melodic trend to simple mathematical formulation was followed by an account of three sets of experiments upon the phenomena of melodic trend in two-tone groups. These trends, with which the feelings of finality or of lack of finality are closely bound up, were found to be due to (*a*) preference for the lower tone as such as an end tone (phenomenon of the falling inflection), (*b*) preference for a return to the first tone as an end tone, (*c*) preference for the expected ending (if one knows that a given tone is to be the last, its arrival may be sufficient to arouse the feeling of finality quite apart from the operation of any other factors), and, finally, (*d*) preference for an end on one of the tones of the tonic chord—and especially the tonic itself—of the suggested tonality.

This formulation, contrasted with the formulation in terms of 'the law of the number 2,' has the advantage of covering more of the observed facts[1] and the disadvantage, as some will consider it, of conceding that the phenomenon described is

[1] For example, the numerous instances in which 8 : 9 and 15 : 16 are judged to end better on the tone which is not a power of 2.

probably not elemental, primitive, but rather a resultant, traceable to the laws of habit and the harmonic structure of the music with which the observers were acquainted. According to this view, the laws of consonance are primary, not the laws of melodic "relationship."

This latter view finds confirmation in the instances cited where the feelings of "relationship" and of trend were clearly the outgrowth of habituation, of repetition, of custom, of association, of mere expectation.

Mention was made of the high importance which seemed to attach, in the introspections of certain of the observers, to kinaesthetic factors present in their experiences of tonality, "relationship" and trend. These facts, together with the fact that the phenomena of "relationship" are exhibited by pairs of tones which vary so widely from the simple ratios, suggest that it is not the sensory but the motor phase of the circuit which contributes the unity,—that it is not the relatively economical activity of the sensory nerves, but the relatively unified response of the motor mechanism which gives rise to the feeling of "relationship."

Our problem, then, shapes itself as the task of studying the motor responses which melodic stimuli elicit, to discover whether here is to be found any further clue to the explanation of melodic unity.

PART III

EFFECTS OF MELODIC STIMULI UPON MUSCULAR MOVEMENT

§23 To gather definite data regarding the relation of movement to the melody experience, the following experiments were undertaken, designed to test the effects of simple melodic stimuli upon on-going motor processes, voluntary and involuntary.

The voluntary process studied was the tapping movement of the index finger of the right hand. This movement was chosen because of its simplicity and naturalness, and because after a little practice it tends toward automatism, leaving the attention free to be focussed upon the stimulus. Such devices as the Jastrow automatograph and the Delabarre muscle-recorder were rejected in favor of the means here described, because it seemed highly probable that changes in innervation would become most readily manifest as alterations of a motor process already going forward. Other factors remaining constant, it is to be expected that a neural current will tend, at least in part, to find its way out of the central system along that motor channel which is already in use. Moreover the investigations of Stetson[1] and others upon complex or "combined" rhythms have made it certain that a concurrent movement coming into coördination will affect an accompanying uniform movement.

The form of apparatus used is an adaptation of the simple device employed by Stetson for recording rhythmical movements. The hand and forearm rested naturally upon the arm-rest leaving the index finger free to move throughout its entire range of flexion and extension without contact. (See accompanying figure). This free, unrestricted movement was chosen because it was found that when the finger taps against a hard surface the contact sensations serve as a

[1] R. H. Stetson: "A Motor Theory of Rhythm and Discrete Succession." *Psych. Rev.* 1905, *12*, 250.

sensory control which regulates and steadies the movement. As our purpose was to detect any slight variations which the melodic stimuli might produce in this motor process, it was obviously better to avoid as many of these controls as possible.

The periodic movement of the finger was recorded in all its details as far as changes in rate, form, and amplitude of movement in a vertical direction are concerned, by means of the recording device above mentioned. From the leather finger-cot a silk thread ran over a tiny pulley and through

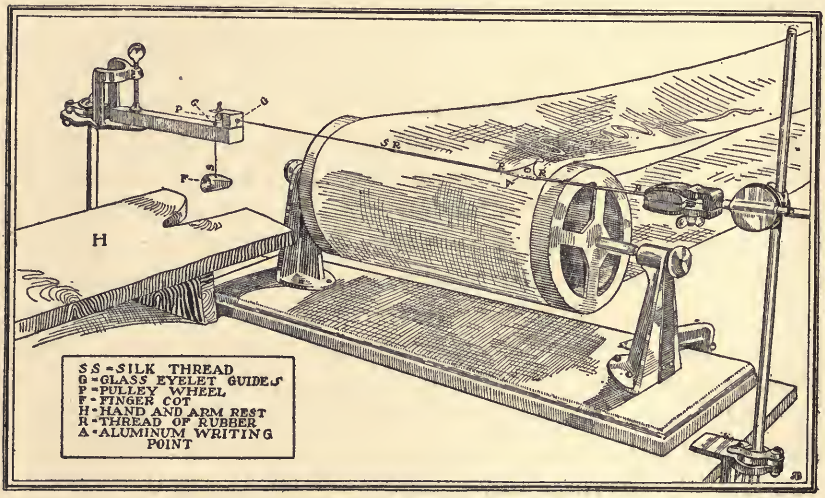

FIGURE No. 1

glass guides which prevented any loose motion. This thread led to a rubber thread, in the middle of which was an aluminum writing point, which traced a record of the finger movement upon the belt of smoked paper. A slight torsion of the rubber served to keep the writing point against the surface of the kymographic belt. By varying the length of the rubber on either side of the writing point the relative amplitude of the curve could be made as small as desired. Most of the records, however, were taken with all of the rubber upon one side of the writing point so that the curve was equal not only in form but also in amplitude to the vertical

component of the finger movement. The tension of this delicate rubber was so slight that it was barely perceptible to the observer, and did not interfere with the freedom and naturalness of the movement. Indeed, the superiority of this recording device over that of a tambour lever lies in the perfect freedom of lateral motion allowed; because there is no restraint upon the finger movement, there are no sensory controls other than those cutaneous and kinæsthetic sensations due to the movement itself.

The belt of smoked paper ran between two cylinders placed about two meters apart. It was driven by an alternating current, constant-speed motor whose only variations were due to fluctuations in the rate of the generator of the Cambridge lighting plant. Tests with vibrating forks of 50 d. v. and 500 d. v. showed that the maximum variations in the rate of the belt of smoked paper were less than one and one-half per cent. As a precautionary measure, however, a time line was made a feature of all the records, interruptions at periods of one second being furnished by means of a Lough self-actuating pendulum, placed in a distant room.[1] Precaution was taken to banish all sound which might arise from the recording apparatus, such as the ticking of the electric markers. The driving mechanism was placed outside of the experimenting room, as otherwise a low hum from the motor could be heard even when it was encased in a "sound-proof" box.

One electric marker, as has been said, furnished the time line. This line also served as base line for measuring amplitudes. Another marker was in circuit with the keyboard of the harmonium which was used for giving the melodic stimuli, and furnished the record of the course of the experiment.[2] A silent pendulum was used to aid the experimenter in controlling the length of the sounds. The smoked record was

[1] Only alternate taps of the time-marker, i. e., one every two seconds, are visible in the sample records reproduced on p. 51.

[2] It is the opinion of the experimenter that a simple pneumatic attachment to the keyboard of an organ or piano with tambour recorder would on the whole prove more satisfactory than an electrical attachment.

made permanent by being sprayed with a ten per cent solution of gum sandarac in alcohol.[1]

Pneumographs of the Sumner pattern were employed to record the abdominal and thoracic breathing. The degree of sensitivity of pneumographs and tambours is shown by the clearness with which the pulse-beat appears on the pneumographic tracings, quite plainly enough indeed, especially on the curve of the abdominal breathing, to permit the computation of the pulse rate if desired.

Nothing of significance for the present investigation appeared, however, in these pneumographic curves. The reason doubtless is found not in the fact that melodic stimuli do not produce important modifications in the breathing, but rather in the fact that the duration of the stimulus used was too brief to permit the characteristic alterations to appear. In this respect the conditions were quite the reverse of those in the experiments of Foster and Gamble.[2] These experimenters using musical selections of various kinds as stimuli found that listening always tends to shorten the expiratory pause and to make the breathing faster and shallower, but not steadier; but no remarkable differences were found in the effects of loud and soft or major and minor music. One is not surprised to learn that characteristic breathing phenomena could not be isolated when use was made of such highly complex stimuli as actual musical selections.

§24 When the subject had taken his place and the pneumographs and finger apparatus had been adjusted, the nature of the particular experiment to be performed was explained. The number of tones which were to be used was told, but nothing further was said regarding the nature of the melodic intervals. The subject then closed his eyes and the experimenter started the kymograph, so that a brief record of the breathing was obtained before the finger movement began.

[1] The double-glazed paper used was too thick to be fixed by the usual device of painting on the wrong side. The use of a spray proved to be convenient and expeditious. A "fixative spray," to be had for ten cents at any art store, when fitted to a foot-power bellows, proves very satisfactory.

[2] Eugenia Foster and E. A. McC. Gamble: "The Effect of Music on Thoracic Breathing." *Amer. Jour. Psych.*, 1906. *17*, 406.

At a word from the experimenter the subject began the tapping movement taking whatever rate was most natural to him. After the tapping had continued for twelve seconds or longer the melodic stimulus was given. The tones were played upon a reed organ the mechanism of which was in electrical connection with a marker which recorded the instant of depressing and raising the keys. The general plan was for the experimenter to sound each tone for a period of three seconds. It may be thought that this period was unnecessarily long, but the observers did not find it objectionable and it has two very obvious advantages. In the first place a period as long as three seconds is sufficient to permit any motor changes which the stimulus may produce to become evident in the record of the finger movement. And in the second place the use of the three-second period minimized, if it did not indeed entirely rule out, the factor of rhythm. Stimuli whose rate is as slow as one in three seconds do not tend to become rhythmized.

After the melodic stimulus the tapping was continued for ten seconds or longer. The observer was then called upon to give his introspection. Aside from a general introspective record of the course of the experiment, the naturalness of the tapping, effect of external disturbances, and the like, the points toward which inquiry was especially directed were two: first, does this melody end? Has it the characteristic of finality, or is it unfinished? Does it leave you in suspense? Does it demand something further? Secondly, the question was raised as to whether or not the melody was pleasing. In many cases but not in all, these two aspects, the affective and the aspect of completeness, seemed to be felt as identical; that is to say, a melody was judged to be agreeable because it came to a good ending, or to be unsatisfactory because incomplete. Not infrequently, however, one met with introspective reports like the following: "That is good; I like that but it is not finished," or, " That isn't particularly pleasant, but it ends very emphatically."

A word ought to be said about the way in which the observers were first brought to an understanding of the phenomenon

which was under investigation. They were not told what the phenomenon was, and then asked if they could observe it. On the contrary, the plan employed was to play an interval of an ascending fifth and then to play the same interval descending and then ask for a full introspective account. Some observers would quickly detect the feeling of relaxation, of repose, of completeness which accompanied the perceptiom of the descending fifth and which was lacking when the ascending fifth was heard. Lest they should immediately form the opinion that this characteristic of finality always accompanied a descending interval, the perfect fourth was next played. This interval they soon discovered makes a better ending upon the upper tone than upon the lower. Only after the observers had become thoroughly familiar with the phenomenon were they asked to serve as reagents in the main experiments. With two of the observers not a little persistence together with many repetitions of the intervals was required before they discovered the phenomenon, but in every case it was a genuine discovery of their own, and was not suggested to them.

§25 The observers were research students or instructors in the Harvard Psychological Laboratory, with the exception of Po., who had, however, had training as an observer elsewhere. All with the exception of Da. and Pu. were men.

It will be convenient to divide the observers into three groups according to musical ability. This classification is based upon tests in recognition and vocal reproduction of melodic intervals, immediate memory for intervals and for short melodies, and recognition of the fundamental note of a chord.[1] The method employed in this last test was as follows: a three-clang chord was played, and after it a single low clang, with the question, "Is this the fundamental basic tone of this chord? Does it, in a way, represent the whole chord? If you had to supply a bass to this chord, is this the tone you would use?" Twenty four chords were given, eight in the first position, and eight each in the first and

[1] The writer acknowledges indebtedness to Professor Meyer for the suggestion of this test of musical ability.

second inversions. The low tone which followed was always a lower octave of one of the tones of the chord, and in one half of the instances it was the fundamental. The number of right judgments for each observer is given in the second column of the accompanying Table 3. The percentages in

TABLE NO. 3

Tests of musical ability.

	RECOGNITION OF FUNDAMENTAL OF CHORD				VOCAL REPRODUCTION OF FUNDAMENTAL TONE			
Observers	Right	Wrong	Doubtful	Per cent	Right	Wrong	Doubtful	Per cent
Po........	24	0	0	100	24	0	0	100
Rk.......	24	0	0	100	23	1	0	97
Rg.......	22	2	0	92	22	2	0	92
Da.......	20	2	2	88	23	1	0	97
Ho.......	20	2	2	88	17	5	2	75
Fr........	16	4	4	75	18	5	1	77
Ta........	12	8	4	58	12	12	0	50
Mc.......	8	5	11	56	10	10	4	50
Pu........	4	0	20	58	—	—	–	—

(In computing percentages, doubtful cases are distributed equally between right and wrong cases.)

the last column represent the success of the subjects in humming the fundamental tone after hearing the chord, the series of chords used being similar to the one employed in the previous test. Errors were most frequently made when the low note was not the fundamental, but was a lower octave of the highest note in the chord. It was found after the series was ended that fewer errors of this kind are made if the observer is instructed not to give his judgment immediately, but first to image the three tones of the chord separately, choose the fundamental, and then make the comparison with the low tone. On repetition of the test, this precaution served to eliminate all errors from the judgments of Rk., Ho., and Da., but did not operate so successfully with those observers whose auditory imagination is less facile.

The results of these tests when combined with the other

observations on musical ability and with the results of an inquiry into the observers' musical interests, their early training and later musical experience, made it evident that the first three observers on the list had a fair order of musical capacity, although Po. was the only one whose abilities had been much developed by training. The last three observers form a distinct group, since they all fall much below the others in the tests reported in Table 3, and also in accuracy of recognition and reproduction of melodic intervals. Pu. could not even be induced to attempt vocal reproduction. The remaining three observers form an intermediate group. None of the nine were entirely lacking in musical interest, although the range represented was a very wide one. An accurate test of ability in pitch discrimination was not carried through to completion because it became evident that accuracy in the discrimination of small differences of pitch is no indication of musical ability. Po. and Rg. did not serve during the preliminary experiments. Da. and Mc. did not serve during the second half year, and their records are included only in the first of the tables presented here. Each observer served for a period of three quarters of an hour once a week.

The observers it will be recalled were directed to take whatever rate of finger movement seemed most natural to them. The individual differences, and also the individual variations from time to time, proved to be extremely wide. Early in the practice experiments, the tapping of Rk., Da., Ta., and Mc. was much slower than it became later on, and nearly all of the observers showed some tendency to increase the natural rate with practice. Within a series of experiments at a single sitting, Rg., Rk., and Mc. were apt to choose a much more rapid rate for the later experiments, unless they happened to select an unusually rapid rate to begin with. This they were apt to do if they had been walking rapidly or otherwise exercising shortly before, or if they had been under any slight excitement.

Not only do the records show great individual differences in the rate of finger movement, but also in the amplitude and

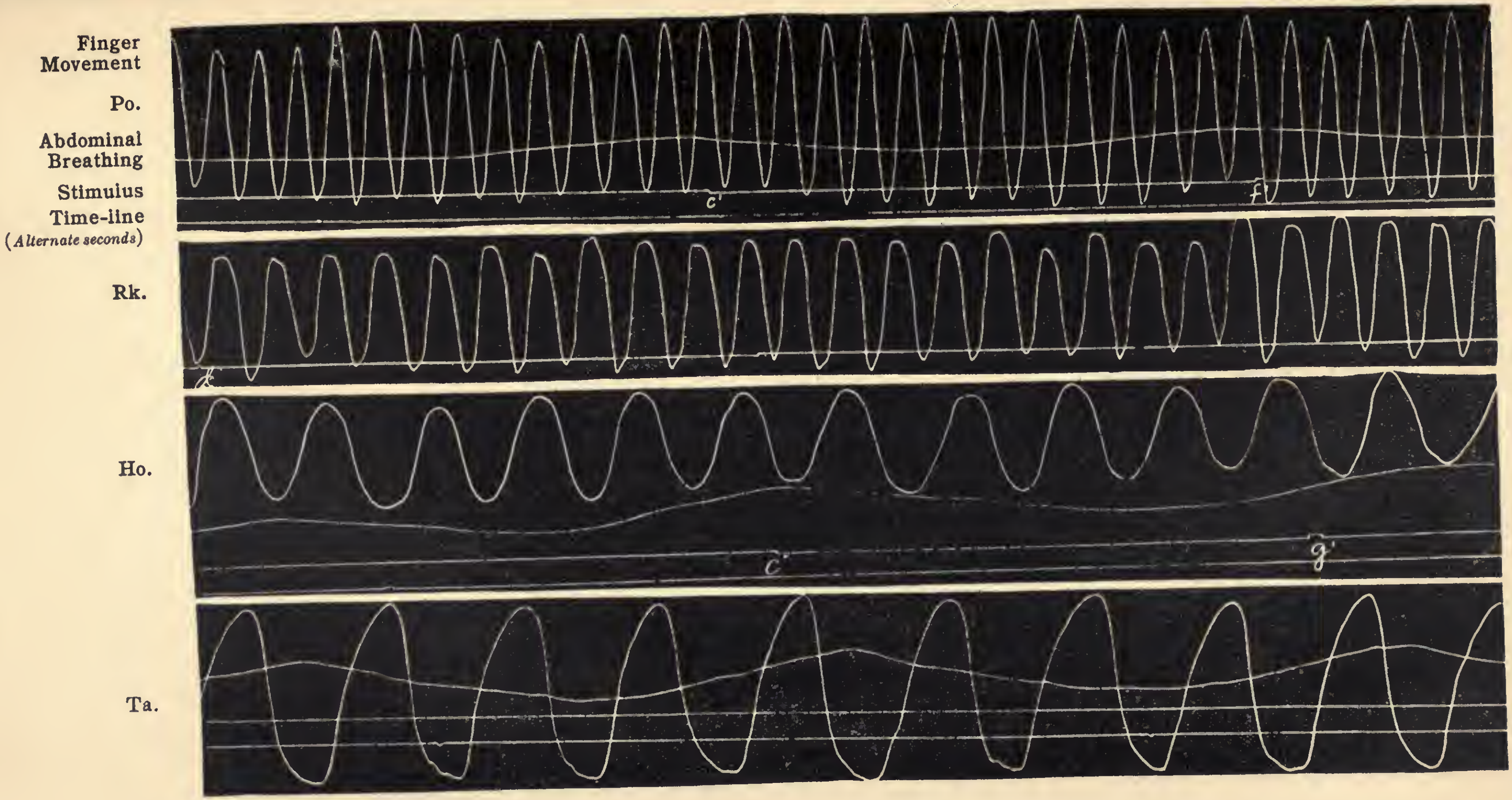

Fig. 2. Reduced one-half.

the general form. Ta.'s record is characteristically slow, wide, and extremely regular. The back stroke is similar to the beat stroke in every respect, and the transitions from the ballistic part of the movement to the controlled portion are smooth and even. The tapping of Da. and Mc. is also slow and wide, but very different from that of Ta. because the ballistic strokes are made with a jerky movement, and the portions of the curve between the ballistic strokes are very irregular. The muscular coördination is much less accurate. Ho. and Pu. also use a characteristically slow rate, but the amplitude of movement is small. One finds very considerable variations in amplitude in the records of both these observers. There is also an irregularity of line due to the fact that the ballistic portion of the movement seems to be almost wholly lacking, even from the beat strokes, (*i. e.*, the finger seems to be almost continuously under control of extensor and flexor muscle sets combined.) The maximum velocity of the beat stroke is much less with these observers than with any of the others. Rk. and Rg. are the two who show the widest variations of natural rate from time to time and also the greatest changes in the form of the finger movement. Both of them use a medium amplitude, but this amplitude varies widely. On the whole, their records show that a much greater prominence is given to the ballistic phase in both beat stroke and back stroke. In Po.'s records, which exhibit the most rapid rates of any of the observers, there is very little in the curve other than the ballistic phase: there is almost no pause between strokes. In the records of Fr., on the other hand, there is always between the vigorous ballistic strokes a relatively long relaxation phase during which the movement is extremely irregular: during these periods the finger seems to be not under the control of either the extensors or the flexors.

With reference to the amplitude of finger movement, it may be noted that with the exception of Ta., those who used a wide amplitude were those who had had some practice at the piano.

TABLE NO. 4

Normal record of rate of finger movement, and fatigue record. Rate of tapping during successive periods of three seconds each. Read from left to right. The slowest rates are printed in bold faced type. Fastest rates in italics.

OBSERVERS	NORMAL RECORD									(One minute of unrecorded tapping elapses between normal record and fatigue record.)	FATIGUE RECORD		
Po.....	252	256	256	252	254	**249**	252	260	*263*		**232**	239	235
Rg.....	*107*	104	106	99	101	99	**92**	100	99		106	104	*108*
Rk ...	130	*133*	133	130	133	132	131	**126**	130		124	124	**121**
Da ...	**97**	*115*	101	105	105	100	103	105	104		99	97	98
Ho ...	*96*	93	90	91	90	91	92	94	**89**		**86**	88	88
Fr.....	208	208	**206**	208	207	210	*220*	217	214		221	*225*	224
Ta	78	78	**76**	77	78	80	79	79	*81*		77	77	78
Mc....	84	85	83	86	87	**82**	*88*	85	86		93	91	*96*
Pu.....	112	**102**	104	107	104	104	109	110	*113*		114	*118*	115

§26 In the accompanying Table 4 are given the measurements of a set of records taken without distraction or stimulus of any kind, for purposes of comparison with records in which melodic stimuli were used. Each number gives the rate of finger movement during a period of three seconds. The rate is expressed in beats per minute, which is the same as the method employed in music for designating rates. The numbers, then, represent the metronome rates at which the observer was tapping during successive periods of three seconds each. To facilitate the reading of the table, the rate of the period of slowest tapping within the record of each observer is printed in bold-faced type, and the fastest rate is printed in italics. A glance at the table will show the extremes between which the rate of tapping varied within the course of the period of twenty-seven seconds covered by the record. It will be seen that four of the nine observers exhibit a tendency toward an increase in rate during this time, while an opposite tendency appears in the records of two observers.

The question naturally arises whether the factor of fatigue may not enter in to modify the nature of the tapping movement as the experiment proceeds. This does not seem to be the case when an experiment does not continue for more

than thirty seconds, as was the case with nearly all of those to be described below. For purposes of comparison, however, there is given in connection with the normal record of the accompanying table what may be called a fatigue record. This is really a continuation of the normal records, one minute of unrecorded tapping having been permitted to elapse between the close of the normal record and the beginning of the fatigue record. During this interval the rate of tapping of four of the observers showed a diminution. With four of the others an increase in rate is seen. The record of Fr. showed the greatest variability and irregularity during this closing period. Only two observers, Da. and Mc., reported any feeling of fatigue after this experiment.

Fatigue makes its appearance very quickly if a rate more rapid than the natural rate of tapping is employed. When the reagent taps as rapidly as possible the entrance of fatigue brings with it a slowing of the rate and an increase in irregularity of rate and of amplitude.

§27 Tables 5 and 6 exhibit the effect of auditory stimuli upon the rate of tapping. These tables are prepared in a manner similar to the table of normal tapping; each number represents the rate of tapping during a three-second period. Measurements of the first few taps of each record were not made because they are certain to be more or less irregular. Measurements of the rate of tapping are given for three periods of three seconds each before the incoming of the stimulus. The stimulus consisted of the tone *a* sounded for six seconds on the harmonium. Then after an interval of three seconds, this tone was sounded again, this time for only three seconds, but it was immediately repeated and sustained for three seconds longer.

A study of this table should disclose the effects which are produced upon the rate of tapping by a musical sound and also by the repetition of a musical sound. It will be noticed that in the records of four of the seven observers there is a marked diminution of rate following the entrance of the first stimulus. The record of one observer shows a marked increase of rate at this point. In all cases there appears to be a tendency

TABLE NO. 5

Effect of a single tone, and of that tone repeated, on rate of finger-movement. The rate during each three-second period of the experiment is given. Read from left to right. Numbers showing decrease in rate at critical points in the record are printed in bold face type; increases in rate are printed in italics.

				a (6 SEC)			a (3 SEC)	a (3 SEC)		
Rk........	136	140	141	**123**	*130*	132	132	*135*	132	138
Da........	101	109	104	**82**	*96*	80	78	**73**	(97)*	90
Ho........	79	81	80	79	78	**75**	**72**	72	71	69
Fr........	159	157	157	**155**	155	**153**	**150**	151	150	152
Mc........	122	116	118	*128*	125	**118**	121	*127*	129	130
Ta.........	77	77	76	**69**	*75*	77	76	76	77	80
Pu.........	60	62	69	66	65	65	66	67	*72*	72

*Stopped tapping for 1.2 sec. when tone stopped; and then began at rate of 97.

TABLE NO. 6

Effect of sudden noise on rate of finger-movement. Entrance of stimulus at beginning of fifth three-second period of the record.

					NOISE			
Po..............	216	216	214	218	*226*	216	214	210
Rk..............	150	154	153	152	152	153	160	159
Ho..............	116	116	114	113	**104**	119	114	116
Fr..............	202	187	185	190	*198*	194	194	197
Ta..............	69	72	71	72	**67**	69	70	70

to return to the original rate while the tone is still sounding. The records of three observers show another diminution in rate immediately following the cessation of the stimulus, but no decided change occurs in the other four records at this point. With the entrance of the stimulus the second time a retardation occurs in three records, but this time it is not nearly as large as in the first instance. The repetition of this stimulus is accompanied by an increase in the rate of one observer and a decrease in the rate of another, the rates of the other five observers not changing materially at this point in the records. The cessation of the stimulus, however, is accompanied by an increase in the rate with two observers, and a decrease in a single instance. One observer stopped tapping entirely for a brief time when the stimulus stopped and then began again at a rapid rate.

It thus becomes evident that under the conditions of this experiment the entrance of an auditory stimulus introduces a disturbance in the process of tapping which shows itself as a change in rate, usually of the nature of a retardation. The nature of the disturbance to the tapping is made very evident by direct inspection of the kymographic records. The next tap after the one during which the stimulus enters is frequently the slowest and also has the greatest amplitude of excursion of any tap on the record. The entrance of the stimulus a second time, after a pause, produces similar but much less marked effects; and when no time interval elapses between the clang stimulus and its repetition no effect whatever is apparent.

The effects of a momentary noise as a distraction are illustrated in the experiments summarized in Table 6. Here, too, a marked change of rate appears in nearly every instance. The solitary exception is Rk., and a closer examination of his record than the table permits shows clearly that here too the the stimulus had its effect. The tap immediately following the one in which the stimulus entered is the slowest tap of the record, but in this instance it is followed immediately by taps of a more rapid rate which bring the rate for the entire three seconds up to the figure given.

It seems to be a general tendency, then, for alterations in the natural tapping rate of the finger to occur upon the entrance into consciousness of an auditory sensation. This very natural phenomenon does not call for an elaborate explanation. It may be dismissed by referring it to that large group of experiences which have as their most prominent feature the characteristic of "shock," of sudden disturbance of equilibrium demanding an adjusting act of attention, and which consequently interfere more or less with pre-existing adjustments and on-going activities. Stated in strictly neural terms, the phenomenon is reducible to an instance of the general law of diffusion, the auditory stimulus introducing a shift of neural tensions throughout the cortex, and more particularly affecting those localities in the Rolandic region which are active at the time.

The modification of rate shows itself most frequently as a retardation probably because new activities of adjustment result in inhibition of the finger movement through drainage of the neural energies elsewhere. To explain those relatively infrequent instances (15 per cent of the total number) where acceleration follows the entrance of the auditory stimulus, one might assume that the stimulus operates to produce a greater alertness, or heightened general activity in which the tapping movement shares. To explain why the very first tap following the onset of the stimulus is sometimes unusually wide and of long duration, but occasionally the reverse, recourse may be had to the facts brought out by Hofbauer[1] and Cleghorn[2] that an auditory stimulus occurring at the beginning of the contraction phase of a movement augments the movement and this reinforcement makes the total duration of the contraction-relaxation process greater; but if the stimulus enters at the beginning of the relaxation phase of the cycle, the process of relaxation is hastened and the total period is diminished.

§28 We may now turn to the experiments in which melodic stimuli were employed, asking what significant changes of rate appear, to what extent these variations are the same for the different observers under identical conditions, and especially, what relations exist between changes of rate and the typical phenomena of melody. Do characteristic changes accompany the perception of a melodic interval which is felt to lack finality? How do these changes differ from those produced by an interval which "ends?" Does a succession of two tones which lack melodic "relationship" have a peculiar effect? What of the "return?" What of disappointed expectation? What of the passage to a tone which necessitates a shift of tonality?

Tables 7 and 8 show the changes in rate of tapping which accompany the hearing of the melodic interval of the fourth, *i.e.*, of two tones whose vibration rates are in the ratio 3:4.

[1] L. Hofbauer, *Arch. f. d. ges. Physiol.* (Pflüger's) 1897, *68*, 546.

[2] Allen Cleghorn, "The Reinforcement of Voluntary Muscular Contraction." *Am. Jour. Physiol.* 1898, *1*, 338.

This is one of the most interesting of any of the melodic intervals from a psychological point of view because of the strong sense of finality which it gives when the higher tone is the last. When heard as a descending interval, it lacks this finality, and yet does not leave one wholly in suspense, for it has those elements of finality which are the property of any descending interval as such, and also those which belong to every tone in the tonic chord. Because of this complexity, judgments regarding the finality of the descending fourth are often uncertain and variable. As an ascending interval, however, there is seldom any doubt in the mind of the observer that the group is a completed whole, emphatically coming to an end. It is indeed the only ascending interval of which so broad and positive an assertion can be made. The minor second and minor sixth are the only other intervals at all comparable with it in these respects.

The tables are made up, as were the previous ones, of numbers representing the metronome rate of the tapping movement during successive periods each three seconds in length. The two tones were each sounded for three seconds, and the numbers immediately under the letters which represent the tones consequently express the rate of tapping during the course of the melodic stimulus. To call attention to changes of rate at critical points in the course of the record, use is made of bold faced type where retardations occur, while accelerations are indicated by italics. In deciding whether or not a change of rate accompanying the entrance of a stimulus was sufficient in amount to be of any significance, the writer has taken into account the degree of regularity shown in the tapping of the six seconds preceding, but has neglected the period before that, which was often so near the beginning of the tapping record that the reagent had not as yet found his pace.

Examining Table 7 with reference to the distribution of retardations and accelerations during and immediately following the melodic stimulus, one notices at once that the retardations all occur during the sounding of the tones (six during the first tone and two during the second) whereas all the accelerations are found within the period of the last tone and the

period immediately after it (two during, and six after, the last tone).

In contrast with this table of the ascending fourth, the table of the descending fourth exhibits much less uniformity in the distribution of accelerations and retardations. The most striking feature is the large proportion of retardations which occur during or immediately after the sounding of the second tone.

TABLE NO. 7

Perfect Fourth, ascending. Rate of tapping during successive periods of three seconds each. Read from left to right. Bold faced type indicates retardation and italics acceleration, at critical points.

				c'	*f'*			
Po..............	207	208	212	212	*222*	225	223	220
Rg..............	94	95	94	**91**	92	*96*	96	93
Rk..............	101	106	104	**102**	**99**	*101*	96	99
Ho..............	105	103	103	**92**	93	*101*	102	100
Fr..............	190	192	186	**180**	**172**	*185*	179	182
Ta..............	76	75	86	**73**	72	*87*	78	78
Pu..............	118	117	120	**112**	*118*	*122**		

*Stopped tapping

TABLE NO. 8

Perfect Fourth, Descending.

				f'	*c'*			
Po..............	248	255	258	**253**	258	**250**	256	258
Rg..............	91	93	95	96	97	96	95	94
Rk..............	104	101	98	*103*	103	**101**	101	103
Ho..............	95	97	99	99	*103*	104	100	101
Fr..............	220	214	219	**213**	**210**	*218*	213	218
Ta..............	82	84	85	**80**	**74**	73	77	80
Pu..............	100	106	105	105	**101**	*116*	114	116

§29 The significance of these facts appears when they are brought into comparison with the results of the previous group of experiments. There it was found that a repetition of a musical sound following shortly after the cessation of the original stimulus produces effects similar to those of the first sound, but much less marked. And when one musical sound is immediately followed by another which does not differ from it in

pitch or intensity there is no apparent effect upon the on-going activity, the only changes observable being in the direction of a return to the natural rate.

When successive tonal stimuli differing in pitch are used—in this instance two tones at an interval of a fourth—the characteristic variations of rate, most of them retardations, follow the entrance of the first tone; but when this is succeeded by the second tone, one does not find the same absence of further variations which marked the appearance of a second tone identical in pitch with the first. Instead one finds fresh changes of rate; and upon comparing the ascending fourth with the descending fourth one is impressed with the fact that the accelerations belong mainly to the rising interval, while most of the new retardations accompany the hearing of the descending fourth. This, it will be born in mind, is an interval that "ends" better on the higher tone.

An hypothesis with reference to the significance of these motor phenomena may here be briefly outlined, as follows: (*a*) Attention is an activity which involves both special and general motor adjustments. (*b*) The general aspects of attentive activity are of such a nature as to affect general bodily conditions; and, specifically, (*c*) the rate of a circular motor process (such as the finger-movement) which is going forward semi-automatically, will be affected by these activities, a decrease in rate signifying inhibition, due to increased activity elsewhere, and an acceleration signifying that the task of attention in organizing these activities is being successfully carried out. Retardation or inhibition, it is to be expected, will enter with the appearance of the stimulus demanding attention. Continued slow rate of movement will result if the organizing activities of the attentive process continue to meet with difficulties, while the rate will be augmented as the new adjustments come to be efficiently established.

In terms of this hypothesis, the above facts with reference to the hearing of the rising fourth would be described as follows: Sudden rise in the level of attention at entrance of stimulus, continued attentive activity during the sounding of the tones, and finally, subsidence of attentive activity with the

satisfactory completion of its task; or, stated differently, presentation of a problem of adjustment as stimulus enters, continuance of the process of establishing coördination during the sounding of tones, and then increase of rate signifying the efficient accomplishment of this act.

It is this acceleration accompanying the sense of finality which seems to be of particular significance.

§30 In testing the hypothesis, the introspections of the observers must be taken into consideration, for not always is a melodic interval heard in the same way. What an interval is to the observer depends as much upon the "attitude" with which it is received as it does upon the ratios of the physical vibration rates.[1]

The order of arrangement of the observers in all the tables, it will be recalled, is that determined by the tests of musical ability. Po., the most musical, reported that the ascending fourth, while it has the attribute of finality, is less final than some, *e.g.*, the descending fifth.

"The pitch of the second tone came as a surprise. The feeling of satisfaction came only toward the end of the second sound, after I had got it placed with reference to the first. The instant of entrance of the sense of satisfaction was very marked."

(The rate for the first four taps of this period was 210, for the next four it was 228 and for the remaining three, 232.) This experience might be described as the final acceptance of a second tone as a tonic which when first heard was not so construed. If, during the hearing of the first tone, a tonality feeling gets established with this tone as a tonic—as is very frequently the case—the transition to a tone of different pitch presents three possibilities. (*a*) It may be an "unrelated" tone, foreign not only to the tonality already in mind but also to any other tonality within which the first tone would find a place. In such an instance there can be no melody feeling,[2] for there is no coherence or relevance between the tones; they do not tend to insti-

[1] *Cf. supra*, p. 32 *ff*.

[2] Here, and throughout the discussion of the experiments, it will be understood that these statements are made solely with reference to the experience of observers who are familiar with a harmonic musical system.

tute a common set of expectations; they do not belong to the same whole. (*b*) The second of the two tones may be "related" to the first as to a tonic. It belongs to the tonality already in mind, and consequently it is welcomed, as partially satisfying the expectations of the hearer; but it does not wholly satisfy them. Instead, it only makes more definite and insistent the demand that the first tone shall be heard again, at the end of the melody; it intensifies the original tonality feeling. If the sequence of tones ends here, one experiences the feeling of unrest and dissatisfaction which accompanies disappointed expectation or thwarted intent. (*c*) The second tone may be capable of entering into tonality relations with the first, but not into the tonality of which that tone is the tonic. This necessitates a shift of tonality. In place of the organized set of expectations already present, a different set appears. The extreme instance of this peculiarly subtile and elusive process occurs when the second tone becomes itself the tonic of a new tonality, usurping the power and function originally held by its predecessor, and organizing a new set of expectations. Such an instance is found in the interval of the ascending fourth.

Po. was probably not the only observer who experienced this peculiar shift of tonality upon hearing the interval of the ascending fourth; but he is the only one who detected and described the feeling of transition and the satisfaction which followed. Rg. reported that the interval seemed to him to be rather indifferent, but after hearing $f'c'$ he said that $c'f'$ had more finality about it than he had thought at first. Rk. reports, "That sounds like '*sol do*'; there is no need of a third tone." Ho. "That ends! It is very agreeable." Fr. "That's all right." Ta. found it difficult to give an introspective report. The interval he said was elusive, and it was hard to say just what the effect was. Pu. reported no definite effect of any sort. It must be noted that even in the case of these last two observers an acceleration of rate occurred immediately after the close of the tone.

With the descending fourth we find much less uniformity in the distribution of accelerations and retardations, and also a greater diversity in the introspective reports. The most

striking and important feature is the large proportion of retardations which occur during or immediately after the sounding of the second tone. Po. reports that the interval was pleasing, but not wholly satisfactory because it lacked finality. During the sounding of the second tone his rate recovered from the slowing-up produced by the first tone but after the melody ended there was a retardation. For Rg. the interval lacked finality but as to agreeableness it was indifferent. Rk.'s introspections were interesting. "That is all right, but I can't help thinking in three's." That is to say, he gave an intellectual judgment that the interval was complete but really felt a need for something further. (Note the retardation in rate.) Ho. says, "I should like to add a third note but it is not bad." Fr., "Unfinished, but pleasant as far as it goes." Ta. "I cannot decide. I keep changing my mind. It is a puzzling interval." Pu., "Very definitely complete and pleasant."

If one examines the table in the light of these introspective comments, it is found that five of the seven records support our hypothesis with reference to the motor effect of the finality experience.

With all of the remaining tables the introspections are presented in very brief summary. The observer's own words are used, as far as the necessities of condensation allow.

§31 Tables 9 and 10 should be examined together. They show the effects produced by the melodic interval of the perfect fifth, ascending and descending. With regard to the aspect of finality, all the observers with the exception of the two least musical ones are agreed that the ascending fifth is lacking in completeness. In spite of this fact, the proportion of retardations and accelerations during the period while the second tone was sounding and immediately after, do not show a balance in favor of the retardations. The lack of finality in this interval is not sufficiently marked to produce the vivid experiences of tension which characterize the perception of some melodic intervals. A more significant reason why one should not expect a larger proportion of retardations here, will become evident shortly.

TABLE NO. 9

Perfect Fifth, Ascending. Rate of tapping during successive periods of three seconds each. Read from left to right. Numbers showing decrease in rate at critical points in the record are printed in bold face type. Increases in rate are printed in italics.

				c′	g′			
Po	225	224	225	224	*228*	*236*	236	230
Rg	129	130	127	126	125	*132*	124	128
Rk	117	117	118	119	**116**	115	114	118
Ho	102	110	111	**104**	**96**	*102*	105	104
Fr	234	233	235	*237*	**231**	232	226	230
Ta	73	74	76	**71**	*77*	*80*	81	83
Pu	102	109	108	**105**	*111*	**104**	103	

Introspections.

Po. A sense of finality, but not completely final. Pleasant.
Rg. A beginning, not an end. Wanted to go on.
Rk. Want to hear first again.
Ho. Needs third tone. Not extremely bad.
Fr. Unfinished. Pleasant.
Ta. That is finished! Felt so the instant it sounded.
Pu. Fairly complete. Agreeable ending, but I do not like so wide an interval.

TABLE NO. 10

Perfect Fifth, descending.

				g′	c′			
Po	197	204	208	**204**	*208*	*214*	219	220
Rg	129	125	135	132	**125**	*134*	133	143
Rk	106	108	108	**102**	101	*105*	103	105
Ho	109	113	111	**107**	106	*109*	*	
Fr	234	225	220	221	220	220	222	229
Ta	78	78	78	78	78	*83*	83	82
Pu	103	106	113	**101**	**97**	*112*	104	101

*Stopped Tapping

Introspections.

Po. No suggestion of further movement. Satisfactory.
Rg. Left no impression.
Rk. Doesn't need a third. Pleasant.
Ho. Can't say as to finality. Fairly agreeable.
Fr. Incoherent. Unfinished. Unpleasant.
Ta. (Introspection uncertain.)
Pu. Did not demand third note.

Table 10, the descending fifth, presents a much more uniform appearance. Accelerations following the close of the melody occur in every record except that of Fr., which shows no change in rate at this point. The introspections, however, are not as definite, three observers failing to report anything positive regarding the finished, self-complete character of the melody. The only one, however, who found the melody incomplete was Fr., the observer whose rate is the only one to show no increase at this point.

TABLE NO. 11

Perfect Fifth, descending. Three tones expected. Average rate of tapping by three-second periods. Read from left to right.

				g'	c'			
Po.	284	284	275	277	275	**267**	269	269
Rk.	205	202	206	**202**	204	**194**	197	223
Rg.	112	117	117	**113**	112	*128*	118	127
Ho.	108	110	111	111	**105**	**101**	99	100
Ta.	76	76	77	**68**	*70*	*73*	75	73
Pu.	104	108	108	**105**	*108*	**100**	101	104

Introspections.

Po. Amusing. Incomplete.
Rg. A feeling of incompleteness.
Rk. Disappointing.
Ho. Unfinished, because of expectancy of another tone.
Ta. Incomplete. Thought you were trying to fool me.
Pu. Surprised that there were not three. Incomplete.

The records from which Table 11 were prepared were taken at the end of the year's experimenting because it was desired to avoid the suspicious attitude which it might possibly have induced in some observers. One of the details of method, it will be recalled, was to let the observer know beforehand how many tones were to be expected, in order to keep the conditions in this respect as constant as possible. In this final experiment, however, the observer was led to expect three tones, but only two were given, the same two used in the experiment just described. (Table 10). Any changes in rate of tapping produced by *unfulfilled expectation* ought then to become evident by a comparison of these two tables, 9 and 10, and indeed

the difference is sufficiently striking. Instead of uniform accelerations following the tones one finds retardations in nearly every instance.

This, then, may aid us in understanding the accelerations so frequently found where introspection reports that the interval lacks finality. As a melodic interval it is left unfinished, but in so far as the hearer was expecting a certain number of tones and that expectation was fulfilled, the experience as a whole gets a certain completeness and unity. Part, at least, of the adjustments of attention have functioned as intended, and only so much of the total motor attitude as was immediately concerned with the tonality experience as such has to be re-adjusted when the melody comes to an end on what is not a final tone.

The diminished fifth (45:64) was selected as an example of a group of two "unrelated" tones. The testimony of the observers is nearly unanimous that the interval lacks completeness and is disagreeable to hear both ascending and descending. (Tables 12 and 13.) Nevertheless there are a larger number of accelerations than of retardations. A comparison of the "exceptions" with those in the introspective table clears up the difficulty somewhat, but even then it must be said that this pair of tables tells against our hypothesis. The only recourse

TABLE NO. 12

Diminished Fifth, ascending. Average rate by three-second periods. Read across.

				b	*f'*			
Po	265	274	277	**270**	267	270	270	265
Rg	122	114	118	*122*	*126*	**117**	116	115
Fr	247	232	232	*242*	**233**	*247*	239	240
Ta	76	80	78	**72**	73	*76*	78	77
Pu	74	73	75	**65**	*76*	*79*	79	84

Introspections.

Po. A raw rough interval. Associations with Wagner made it less disagreeable. Incomplete.

Rg. Disagreeable because incomplete.

Fr. Not finished but good as far as it went.

Ta. Unfinished but a pleasant interval.

Pu. Very disagreeable. Felt at entrance of second tone.

TABLE NO. 13

Diminished Fifth, descending. Average rate by three-second periods. Read across.

				f'	b			
Po	263	276	265	263	267	*274*	270	267
Rg	116	118	117	115	*131*	130	131	119
Fr	192	200	219	207	**198**	**192**	202	211
Ta	76	78	76	**70**	71	*76*	74	76
Pu	80	79	77	79	**76**	*82*	85	77

Introspections

Po. Incomplete, but not seriously so.

Rg. One more tone (he hummed *c*) would make a great difference.

Fr. Very unpleasant. It seemed complete because you told me there would be but two.

Ta. Finished. A pleasant interval.

Pu. Didn't think about completeness. At first thought it disagreeable, then not sure.

is to the principle that the tapping tends to become rapid whenever attention is freed from the stimulus, irrespective of what the stimulus may be.

The descending major third is an emphatically final melody (although Fr. and Pu. did not so describe it), and the table (No. 14) shows the expected accelerations. The most interesting feature is, however, the marked retardation in the record of Rk. The last tone was a final tone, he said, but he wanted a third tone in *between* the first and second, and tried to figure out what tone that should be. The retardation occurs in the portion of the record where this was being done.

In this and several of the following tables are given the measurements of a single record in which the rate of each separate tap is determined. Samples of the tapping of each of the different observers are thus made available for detailed inspection. It is interesting that the rate for individual taps can fluctuate as widely as it does without greater variability in the rate as measured for periods of three seconds.

The minor sixth (5 : 8) was, somewhat to the surprise of the experimenter, judged to be an incomplete and disappointing melody, ascending as well as descending. It has the

TABLE NO. 14

Major Third, descending. Metronome rate of each separate tap. Read down.

				e′	c′			
Rk.	177	187	202	198	218	178	148	172
	181	163	206	191	202	149	148	182
	168	182	202	185	153	148	246	185
	177	160	179	191	171	159	198	188
	181	164	185	211	176	162	182	171
	176	182	160	209	182	148	153	169
	182	153	190	271	163	159	191	158
	177	171	197	202	132	148	185	172
	182	182	166	226	183		183	148

Average rate for each three-second period. Read across.

Rk.	178	171	185	*207*	**188**	**162**	176	171
Po.	225	222	225	227	229	*237*	230	237
Ho.	100	103	104	**98**	97	*106*	106	102
Fr.	193	195	209	205	206	*213*	195	214
Pu.	80	81	85	**77**	80	*88*	84	86

Introspections.

Rk. Wanted a third tone *between*. Tried to decide what it should be.
Po. Surprising, but very satisfying. Final.
Ho. It became satisfactorily complete after I had thought about it.
Fr. Coherent, but suggested something further.
Pu. Needed a third tone to complete it;

TABLE NO. 15

Minor Sixth, descending. Metronome rate of each separate tap. Read down.

				g′	b			
Ho.	106	103	113	119	109	105	92	111
	117	106	115	104	89	100	103	119
	82	96	105	101	110	102	114	106
	110	117	123	106	128	101	97	102
	111	110	111	110	111	89	106	89

Average rate by three-second periods. Read across.

				g′	b			
Po.	225	220	224	**204**	*222*	222	225	227
Rk.	137	128	135	139	*145*	**130**	130	137
Ho.	104	106	113	108	108	**99**	101	105
Fr.	172	158	181	175	183	183	184	182
Ta.	106	101	105	105	107	**100**	103	105
Pu.	112	111	112	114	*127*	**118**	122	125

Introspections

Po. Surprise and disappointment on second tone. Unsatisfactory.
Rk. Does not end.
Ho. Very noticeably lacked finality.
Fr. Quite unrelated.
Ta. Tone pleasant but melody does not end.
Pu. Unsatisfactory. Incomplete.

TABLE NO. 16

Minor Sixth, ascending. Metronome rate of each separate tap. Read down

				b	*g'*			
Ta.......	80	86	75	81	77	79	79	81
	86	81	83	72	82	77	79	79
	82	81	83	72	79	81	81	82
	81	82	82	73	71	86	81	75

Average rate by three-second periods. Read across.

				b	*g'*			
Rg.......	99	101	104	**98**	101	**97**	99	100
Ho.......	102	108	110	**102**	**98**	98	98	100
Fr.......	208	207	215	*223*	**215**	**208**	201	213
Ta.......	82	82	81	**74**	77	*81*	80	79
Pu.......	97	97	97	**95**	95	*100*	102	107

Introspections

Rg. No melody; no finality.
Ho. Seemed bad at first but changes to a final interval.
Fr. Unconnected and therefore unpleasant.
Ta. Incomplete.
Pu. Unrelated. The second note seemed to change in character.

character of incompleteness very strongly as a descending interval, but when heard in the opposite direction it is possible so to reconstruct the tonality as to make the higher tone a tonic. This, the observers, with a single exception, failed to do.

Consequently Tables 15 and 16 may both be taken as showing the effects of a melody that lacks finality. The unusually large number of retardations strikes the eye at a glance.

§32 Turning now to some examples of three-tone groups (tables 17 and 18), we are confronted at the outset with the

difficulty that it is usually quite possible to interpret any group of three related tones in a variety of ways, and we are thrown back upon the introspections of the observers for a starting point in our interpretation of the results. This method has its obvious disadvantages, notably those resulting from the probably imperfect reports which the average observer can give about so complex an experience as the course of a three-tone melody.

TABLE NO. 17

Three-tone groups. Average rate for each three-second period. Read across.

				g	*e′*	*c′*			
Rk........	140	143	141	142	141	*146*	*153*	147	142
Ho........	122	118	116	**109**	*117*	118	116	118	112
Ta........	71	74	71	70	*76*	*87*	88	75	72
Pu........	123	120	135	**114**	*128*	127	127	121	138

Introspections

Rk. Finished. Very good melody.
Ho. Complete, satisfactory.
Ta. Incomplete.
Pu. Uncertain.

TABLE NO. 18

				g	*e♭′*	*b♭*			
Rk........	130	131	126	*132*	*139*	*151*	*170*	139	136
Ho........	110	118	113	112	*115*	**111**	*118*	112	118
Ta........	70	70	68	**63**	*67*	*76*	**66**	66	66
Pu........	145	144	154	**138**	142	*148*	**141**	146	151

Introspections

Rk. Leaves me in suspense.
Ho. Unfinished. Don't like it.
Ta. Second note did not fit in at all. Very disconnected.
Pu. Fairly good ending, but the intervals are too wide.

The two melodies placed together here for comparison are very similar in form, and both are made up of wide, consonant intervals, but one of them, the first, seemed to the experimenter to have a more positive finality. The more musical

observers agree with him in this. All of the retardations (neglecting of course those which accompany the entrance of the first tone) occur at the end of the less final of the two melodies.

On the whole these tables are not very illuminating.

TABLE NO. 19

Three-tone groups. Average rate for each three-second period. Read across.

				c′	*a*	*b*			
Rk........	154	152	160	**154**	*159*	*174*	**166**	179	160
Ho........	115	107	109	*112*	**105**	**86**	*96*	110	104
Ta........	69	71	71	70	71	72	70	70	71
Pu........	103	105	105	**96**	*102*	101	*109*	114	114

Rk. Unsatisfactory. *Must* go back to first tone.

Ho. Perfectly horrid! Due to the last tone.

Ta. Could give no introspection. (Note regularity of rate.)

Pu. Indifferent.

TABLE NO. 20

				c′	*a*	*b♭*			
1 Rk......	164	160	159	*173*	**168**	*180*	**170**	177	168
2 Rk......	159	156	157	**149**	145	146	*155*	171	168
3 Rk......	178	180	184	**179**	180	*187*	188	181	181
Ho........	97	102	106	104	**99**	*103*	101	100	104
Ta........	77	80	77	**73**	75	*87*	85	78	85
Pu........	97	99	98	*100*	**97**	*111*	**106**	99	98

1. Rk. Wrong, but not very bad. Second note spoiled it.

2. Rk and 3 Rk. (repetitions at a later date of same tones.) Both satisfactory and complete, the latter reassuringly so.

Ho. Last note predominates and becomes satisfactory ending.

Ta. Indifferent ending. Last note a disappointment.

Pu. Tones seemed disconnected.

Table 20 is of interest mainly because it shows the different reactions which the same melody elicited from one of the subjects at different times. The group of intervals, c′-a-b♭, is one which demands a shift of tonality, but which then ends, satisfactorily. When it was first given, Rk. did not so hear the melody: the tonality did not become readjusted. Two weeks later the experiment was repeated and this time the tones were heard as a complete melody. It was immediately given again, with similar but more positive introspective

reports as the result. The three records show the expected differences in the tapping.

A striking record is that of Ta. (Table 19). He tapped throughout the course of the experiment almost with the regularity of a ruling engine. When asked for an introspective report, he could find nothing to say! The tones had had no effect whatever.

Every retardation shown in these tables finds its explanation in the introspective records. Not quite as much can be said for all of the accelerations.

With table 21 we take up the study of the "Return." The interval here used is the major second (8: 9). This is a very satisfactory melodic figure when the lower tone is the start-

TABLE NO. 21

Three-tone group. Major second. Average rate for each three-second period. Read across.

				d′	*c′*	*d′*			
Po........	248	244	249	**242**	**218**	*229*	*244*	253	251
Rk........	192	195	191	**171**	170	170	*176*	183	187
Ho........	109	101	102	**93**	*96*	**92**	*98*	98	102
Ta........	100	107	112	**103**	**98**	*102*	**99**	101	101
Pu........	95	94	98	**89**	91	101	*105*	101	103

Po. Second tone very unpleasant. Third reinstated calm and repose of the first. At loose ends on second. The return changed all this.
Rk. Very unsatisfactory as a whole but had a certain unity about it.
Ho. I think that ended nicely. It is curious that I can not recall the middle tone.
Ta. The lower would have been a better ending.
Pu. Second note not right. Return to first gave feeling of finality.

TABLE NO. 22

				c′	*d′*	*c′*			
Po........	259	265	265	**259**	**254**	*261*	**256**	265	252
Rk........	162	188	181	**164**	**158**	*171*	*178*	192	181
Ho........	114	105	110	**97**	*100*	**93**	*100*	93	
Ta........	114	106	101	*107*	**95**	*102*	*102*	121	115
Pu........	106	118	102	*111*	**96**	95	*108*	100	102

Po. Third tone a pleasant relief from suspense.
Rk. It was all right at the time.
Ho. Very pleasant and complete.
Ta. Positively finished.
Pu. Pleasant and complete.

ing point and the end, and one is not surprised to find a large proportion of accelerations at the close. (See table 22, *c′-d′-c′*.) The record fits well with the introspections.

When the upper tone is made the point of departure and return, the melody tends to fall apart. The middle tone positively will not fit into any tonality suggested by the first. This appears very prominently in the introspective records. Another feature is that *without exception* the observers felt that the return from this lower tone to the upper was very satisfactory. "The third reinstated the calm and repose of the first," etc. The entire set of introspections accompanying this table is recommended for careful perusal as clearly setting forth the result of a return from a tone felt to be foreign to the first. The experience acquires a unity which is most certainly *not* contributed by any interval "relationship."

TABLE NO. 23

Three-tone groups. "The Return." Average rate for each three-second period. Read across.

				c′	*f′*	*c′*			
Po........	285	260	254	*259*	**244**	**238**	*248*	256	258
Rk........	154	162	164	*168*	**160**	*171*	*178*	176	167
Ta........	82	83	81	**76**	*79*	78	**74**	76	84
Pu........	99	105	110	**96**	*110*	**99**	*113*	107	108

Introspections.

Po. Much less complete than if upper tone were last.

Rk. Satisfactory ending, but not so good as *f-c-f* (hummed).

Ta. Finished.

Pu. Incomplete. Second tone unrelated to others.

TABLE NO. 24

				f′	*c′*	*f′*			
Po........	249	249	249	**236**	234	*254*	*259*	261	262
Rg........	119	126	126	**123**	*127*	**123**	*126*	128	126
Rk........	171	180	183	**172**	170	*176*	176	181	
Ta........	79	76	75	**72**	70	*73*	72	75	76
Pu........	81	86	87	*90*	**86**	*90*	*101*	97	96

Po. Emphatically final.

Rg. O. K. Finished.

Rk. Fairly satisfactory. More so than *c-f-c* (hummed).

Ta. Fairly complete.

Pu. Complete.

TABLE NO. 25

Three-tone groups. "The Return."
Rate for each separate tap. Read down.

				c′	g′	c′			
Po........	243	274	242	240	267	236	248	236	252
	285	267	246	253	236	254	246	229	267
	262	258	226	260	240	244	276	204	267
	265	260	226	247	256	252	265	223	246
	258	222	239	252	276	254	263	213	242
	260	232	221	262	262	269	236	229	254
	272	252	224	248	267	278	247	256	254
	265	254	253	233	260	250	260	265	243
	260	236	236	233	231	250	252	260	267
	276	221	236	252	269	248	233	256	240
	272	224	258	276	277	224	270	250	272
	269	232	242	272	256	228	260	258	253
	272	226	240	272	258	240	234	246	254

Three-tone groups. "The Return." Average rate by three-second periods. Read across.

				c′	g′	c′			
Po........	268	238	238	254	258	248	251	240	254
Rk........	118	118	119	**116**	118	*128*	**115**	117	
Ho........	79	80	79	78	80	*82*	*93*	95	95
Fr........	208	203	200	199	196	*206*	207	200	198

Introspections.

Po. More or less complete. Not very good.
Rk. O. K. Finished.
Ho. Complete. Very pleasant.
Fr. Complete, but not wholly satisfactory.

A study of the table of rates itself is equally illuminating. In number and distribution of accelerations, it is almost identical with the companion table, where the return was from a tone felt to be quite coherent with the first tone of the melody.

Tables 23–26 also show the effects of the return to the starting point. The intervals used differ from the preceding in that they are wider, and consonant intervals. The fourth (tables 23 and 24) ends more emphatically upon the upper note, the fifth (tables 25 and 26) on the lower. This was the judgment of the observers. The small sprinkling of retarda-

tions at the close of these melodies would indicate that this difference in finality is unable to maintain itself,as against the two factors that tend to exert an opposing influence upon the tapping, the factors, namely, of the return, and of the fact that the expected number of tones was heard and nothing further anticipated.

TABLE NO. 26

				g'	c'	g'			
Po.........	230	230	237	**227**	**208**	*239*	*246*	251	
Rk.........	138	138	140	**131**	*140*	139	**136**	128	
Ho.........	77	78	80	79	**77**	*80*	*86*	84	
Fr.........	204	197	196	197	**193**	195	193	196	203
Ta.........	74	74	80	74	73	*76*	*81*	75	81
Pu.........	106	105	107	**103**	102	*116*	*119*	110	108

Po. No feeling of finality; therefore unpleasant. No tendency to go elsewhere.
Rk. Not as complete as c'-g'-c' (hummed), but one isn't left in suspense.
Ho. Can't say as to completeness. Unpleasant.
Fr. Incomplete.
Ta. Better to end on second note.
Pu. Not emphatic finality; only such as any 'return' gives.

What of the octave? Meyer was unable to detect any stronger "trend" to the lower than to the upper tone, and consequently put himself on record as opposed to Lipps and the other writers who assert that the lower tone possesses the stronger finality.[1]

The question was put to each of my observers. They were asked to judge with reference to the finality of ascending octaves, descending octaves, and also groups of three tones, involving the return. Intervals in the middle region of the scale and also in the great octave were used. The results were strongly against Meyer's view. Pu., the least musical of the observers, could detect no difference in finality between the end on the upper and the end on the lower of two tones an octave apart. All others found that a stronger feeling of finality attached to the end on the lower tone. This dif-

[1] *Psych. Rev.* 1900, 7, 248. In the light of his more recent studies on the effect of the falling inflection (see above, p. 28) we suspect that Meyer would today formulate somewhat more guardedly his statements regarding the psychological effect of the close on "1" and on "2."

ference of preference does not make itself evident, however, in the tapping records of tables 27 and 28 (the octave). At the close of the melody there is found almost exactly the same preponderance of accelerations over retardations in each of the two tables. Although one ending is better, both are good.

TABLE NO. 27

The Octave. Rate of each separate tap. Read down.

				c′	c″	c′			
Rg........	90	93	96	88	83	70	81	85	86
	81	83	93	85	93	83	92	93	90
	88	88	95	93	81	88	97	83	83
	93	88	88	81	79	81	86	90	85

Average rate for each three-second period. Read across.

				c′	c″	c′			
Rg........	88	88	93	**86**	**83**	85	*88*	88	86
Po........	258	252	254	**245**	**238**	239	*257*	256	284
Rk........	238	232	236	**211**	**204**	205	*210*	218	231
Ho........	120	120	119	**104**	*108*	109	**96**	107	108
Fr........	186	199	199	*205*	*216*	**207**	206	218	210
Ta........	78	81	78	**72**	71	73	*77*	81	79
Pu........	96	93	98	*109*	112	**101**	*112*	120	113

TABLE NO. 28

The Octave. Rate of each separate tap. Read down.

				c″	c′	c″			
Rg........	93	96	91	76	95	90	94	88	98
	95	91	93	93	85	99	99	102	92
	90	90	93	89	88	88	90	92	93
	96	99	94	88	89	85	86	91	90

Average rate for each three-second period. Read across.

				c″	c′	c″			
Rg........	93	94	93	**86**	*90*	90	*92*	93	93
Po........	272	261	277	**245**	**232**	*262*	**254**	256	252
Rk........	251	250	259	256	*262*	260	259	268	266
Ho........		107	108	**102**	**97**	*104*	*106*	111	106
Fr........	198	199	192	*215*	216	**207**	205	206	212
Ta........	81	81	81	**78**	*87*	82	80	81	82
Pu	130	138	116	112	114	114	*124*	120	147

§33 In the last two tables to be presented, Nos. 29 and 30, are shown the rates of tapping during the hearing of a longer group of tones. Here the exact number of tones was not told in advance, the observers being informed merely that they might expect several more than the usual number. The two "melodies" are alike in that they both start and end with "c," and both use the same intermediate tones; but they differ in the order of these tones. The first group moves slowly but naturally forward, and at length comes inevitably to rest on the last of the seven tones. The second moves as slowly and as regularly, and reaches the same goal,—and yet the goal is not the same. Subjectively it is no goal at all. None of the observers knew when it had been reached until the tones abruptly ceased, whereas with the previous group, all but one reported that they knew the last tone was the last as soon as it began to sound. The first sequence, then, is a genuine melody; the second is not.

One or two typical introspections may be quoted as representative of the sort of experience which was more or less common to all of the observers. Rk. (first seven-tone group.)

During the first three notes I did not know what was the melodic meaning or general direction, but on the fourth note it took shape and I anticipated what the next would be, and so on to the last. The last was definitely final. It didn't occur to me that there might have been more tones until you suggested the possibility of it.

(Second group.) The third note was not what I expected. The sixth would possibly have made a good ending. The last note was a disappointment; it wasn't offensive, but obviously was not the best possible.

None were satisfied with the ending of the second group of tones; all thought it more or less incoherent throughout and hard to grasp. But with the first group every observer with one exception was sure, when the last tone had been reached, that that was to be the final tone. The one exception, Pu., could not give a definite answer to the question whether the ending were a surprise or not, whether or not anything further was anticipated.

TABLE NO. 29

Group of tones judged to be a melody. Rate of each separate tap. Read down.

				c′	*e′*	*g′*	*e′*	*f′*	*d′*	*c′*			
Po.....	252	238	236	238	252	228	221	238	258	228	250	248	236
	246	228	235	240	228	220	222	222	256	204	256	236	238
	250	237	236	237	208	220	236	240	240	222	260	256	254
	230	236	237	246	208	233	218	238	251	186	233	246	238
	250	238	238	220	205	211	220	222	246	219	218	256	220
	228	236	232	221	229	220	252	261	236	254	241	254	236
	236	250	256	220	206	233	233	228	246	212	218	236	236
	237	246	258	211	254	220	231	257	228	234	244	236	238
	246	237	252	205	237	224	237	237	245	238	256	254	238
	227	254	257	217	220	217	220	254	256	226	242	234	236
	245	250	252	232	212	203	220	238	238	246	240	234	236
	236	238	257	226	210		220	222	220	236	246	236	244

Average rate for each three-second period. Read across.

				c′	*e′*	*g′*	*e′*	*f′*	*d′*	*c′*			
Po.....	241	244	247	**227**	**221**	219	*227*	*241*	242	**227**	*251*	244	239
Rg.....	98	98	92	95	**90**	89	*97*	**91**	**88**	*93*	*95*	96	94
Rk.....	200	190	196	195	**181**	180	*190*	191	*198*	*207*	205	208	215
Ho.....	87	80	87	80	78	83	82	82	79	*88*	*90*	92	88
Fr.....	205	229	228	222	223	216	**202**	*206*	*212*	212	*216*	206	216
Ta.....	69	70	68	67	**63**	*74*	**68**	66	58	*67*	68	66	69
Pu.....	102	98	105	**97**	*101*	*110*	*114*	**107**	108	**102**	*106*	109	112

TABLE NO. 30

Seven-tone group judged not to be a melody. Average rate by three-second periods. Read across.

				c′	*f′*	*d′*	*g′*	*e′*	*f′*	*c′*			
Po.....	260	254	261	**255**	*276*	**253**	*280*	**238**	*264*	**247**	*260*	253	265
Rg.....		104	108	**103**	*109*	*112*	112	*140*	**114**	**102**	101	105	108
Rk.....	152	153	162	*169*	*172*	168	168	**163**	*169*	**157**	**152**	153	171
Ho.....	102	112	111	**100**	100	102	**99**	101	*106*	*112*	**105**	110	102
Pu.....	117	105	122	117	**110**	*122*	121	**113**	115	*118*	118	125	122

In the tables the changes of rate are shown throughout the course of the melody, but the ones which are of special significance for our purposes are of course those accompanying the strongly contrasted feelings at the end of the tonal sequences. At the close of the first, every record reveals an acceleration in the rate of tapping. In marked contrast are

the retardations found at the close of the other sequence. (See accompanying graph, Fig. 3.)

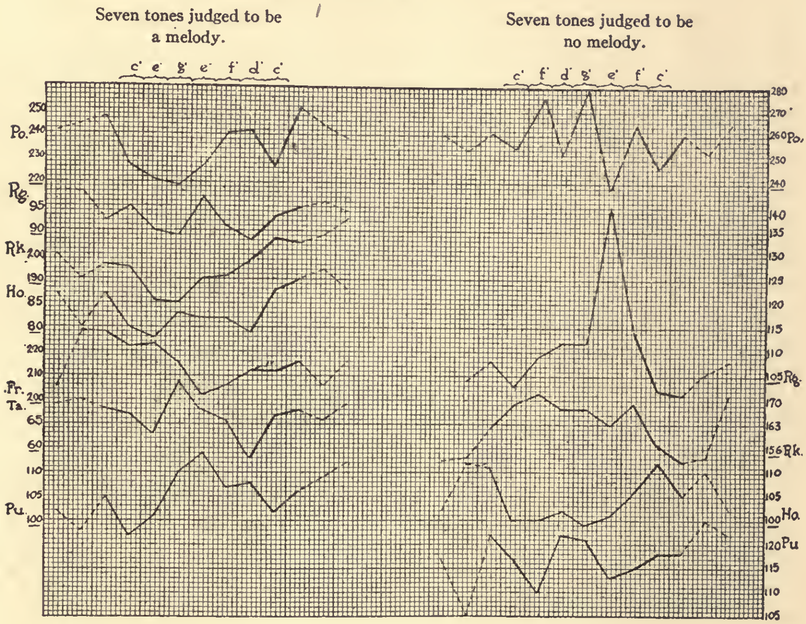

FIGURE No. 3. EFFECTS OF A MELODY AND A NON-MELODY CONTRASTED. Each tone sounded for three seconds. Graphs represent rate of tapping during each of these three-second periods. Note general tendency toward increase in rate at close of melody, and absence of such acceleration at close of non-melodic sequence.

§34 It remains to summarize and evaluate the foregoing experimental data.

The facts which stand out with most prominence are, first the correlation between the beginning of a tonal sequence and a drop in rate of tapping; second, the correlation, nearly as close, between the conclusion of a tonal sequence and an increase in rate in case the observer knows in advance how many tones are to be expected; third, the retardation of rate at the end of a two-tone sequence when the observer has been led to expect three tones, the sequence being one which under the usual conditions produced acceleration instead of retardation of rate; fourth, retardations at the close are much more frequently encountered among those two-tone intervals which

are judged to be "unrelated", incoherent or decidedly "incomplete," than among intervals judged to be melodious, coherent or characterized by finality; (*vid.*, especially, descending *vs.* ascending fourth, ascending *vs.* descending fifth, minor sixth *vs.* major third); fifth, the return to a first tone is felt as giving unity to a three-tone group, and retardations at the close are not often met with, no matter how unrelated and foreign the middle tone may have been; sixth, longer sequences of tones, the pitch relations of whose elements give to them opposite characters as regards internal coherence and finality, produce opposite effects upon the rate of tapping.

In an examination of our data, these six points come to view. The attempts to apply our hypothesis in detail to some of the results must be considered, however, simply as indications toward a possible development of the method into an analytic tool of much usefulness, rather than as bringing forward further positive evidence on the question of the motor aspects of the perception of a melody.

PART IV.

SUGGESTIONS TOWARD A MOTOR THEORY OF MELODY.

Such evidence of the interconnection between muscular activity and melody experience as has been here adduced is too slender to serve as the support of an elaborate and detailed theory. But the broad lines along which a motor theory of melody must some day be worked out may be with propriety suggested here, as harmonizing with the experimental facts in so far as they are available.

§35. Every melody, like every other experience which is a 'whole,' must have, in Aristotelian phrase, "a beginning, a middle and an end." A motor theory of melody finds the 'beginning' in the upsetting of established muscular tensions which the onset of the tonal sequence involves.

The 'middle' includes the taking of the proper 'attitude,' the organization of a set of incipient responses, and then as the tonal sequence proceeds, the making of these responses explicit and overt in the acts of responding to the successive tones. Each tone demands a specific act of adjustment for which a general and also a more or less specific preparation has already been made, and each contributes in turn to the further more definite organization of the total attitude. If a tone appears which is of such a pitch that an entirely new adjustment is necessary, that tone is unrelated: unity is destroyed; the succession of tones is not a melody. But if the new tone is so related to its predecessors that it institutes a response which is in part a continuation of the act already in progress, the unity is preserved.

The 'end' comes only with the arrival of a phase of the complex ongoing activities in which the balanced tensions can merge into each other and harmoniously resolve their opposing strains. This becomes possible when a sufficiently defi-

nite set of expectations has been aroused and then satisfied. Here we find a reason why a close on the tonic has to be 'prepared for,' in musical phraseology, by a 'leading tone' not in the tonic chord. The expectations, the muscular strains and tensions, must be developed to a certain degree of definiteness of organization before a return to the tonic can serve as the cue for a general 'resolution.' '*Lösung*' describes the close of the motor process somewhat better than its English equivalent, relaxation. A single muscle can relax. But this process of muscular *Lösung* which marks the end of a melodic phrase, a spoken sentence, or a rhythmical period, is more than mere relaxation; it is an organized, balanced muscular "resolution," to borrow a very apt technical term from the musicians.

Of some such 'beginning' and of some such 'end,' even so crude and apparently remote a line of experimental attack as the one we have used, has furnished an indication. In order to learn about the nature of the 'middle' muscular processes a more refined way of approach to the delicately complex mechanism of the melody experience must be devised. One would like best of all to record the tensions of the laryngeal muscles when no sound is being emitted. Here doubtless is one of the centers, with many persons at least, of those activities by means of which a series of separate musical sounds is bound together into the unified experience we call a melody. Already some few significant facts have been accumulated regarding vocal tensions during auditory stimulation. Seashore and Cameron have independently demonstrated that a vocal tone sung against an auditory distraction tends to vary toward a pitch which is consonant with the distracting tone.[1]

Is this muscular process whose arousal and subsidence give shape and unity to a melody, a rhythm? It certainly has many of the earmarks of a rhythm,—its motor mechanism, its relaxation following tension, its conscious aspect describable as a satisfaction of expectation—all these would lead

[1] E. H. Cameron. "Tonal Reactions." *Psych. Rev. Mono. Supplements.* 1907, *8*, 287.

one to call it a sort of macro-rhythm, a giant process similar in its essential nature to a rhythm in the usual sense. But there are fundamental objections to such an identification, chief of which are (1) that a rhythm involves *repeatedly recurrent* stresses, with recognition of similarities, as this 'ground-swell' muscular process does not, and (2) that a certain regularity, with possible variations between well-defined limits only, is essential to rhythms. The two phenomena, although both motor at basis, must not be confused.

The experimental study of rhythm has, however, disclosed a motor phenomenon essentially like the large, basic motor activity underlying a melodic unity. I refer to the particular sort of muscular tension-relaxation process which Stetson[1] found to be essential to the unity of a group of rhythmic elements felt to constitute a verse, or a rhythmic phrase.

Using a modification of the principle of the phonographic recorder, Stetson made records of spoken verse, and measured with microscope and micrometer the duration and the relative intensity of the separate syllables.

In unrhymed stanzas the duration of the verse pause was found to vary widely, but it was invariably longer than the foot pause. The typical dynamic shading of the verse was found to be of the crescendo- diminuendo form. The introduction of rhyme often shifted the climax of the crescendo to the final foot by increasing the intensity of the rhymed syllable. Although as great a verse pause was found to be possible with rhyme as without it, the presence of rhyme tended to shorten the verse pause, to bring the verse to a close more rapidly.

Within the verse the general form of the syllable as it appears in the mass of closely written vibrations often varies, but nearly always shows a square end. Several very common shapes are noticed and appear in the record as 'truncated cones,' 'boxes' and 'truncated spindles.' . . . . .One syllable form has an especial interest, because of its bearing on the problem of 'finality' feeling at the close of the verse. At the close of each verse, whether with or without rhyme, the syllable

[1]R. H. Stetson. Rhythm and Rhyme. *Harvard Psych. Studies*, Vol. I. *Psych. Rev. Mono. Suppl.* 1902, *4*, 413.

form is always a 'cone.' Of about 600 verses measured not more than 15 are exceptions to this rule.....................................
The form very rarely occurs within the verse, and when it does it is usually before some caesura, or under unusual conditions.

This 'cone' form of the closing syllable of the verse indicates a falling of the intensity of the voice. It is often, though not always, associated with a fall in the pitch, showing relaxation of the vocal cords. It seems to be an indication of the dying out of the intensity factor, a sinking of the tension, at the close of the verse. In the case of unrhymed verses, with long verse pause, the cone is often very much elongated, and it is quite impossible to say where the sound ceases.[1]

It will not be necessary to treat here of those portions of the motor theory of rhythm which explain, as the central, or "mental activity" theories have failed to do, the peculiar nature of the various sorts of unit groups.[2] We shall briefly sketch only so much of the theory as is requisite to explain the larger groupings such as the phrase, the verse, the period.

Stetson's theory of rhythm assumes a movement cycle involving the activity of two opposing sets of muscles. The varying tension between these muscle sets as beat follows beat never entirely disappears until the close is reached.

The continuity of the rhythmic series, whereby all the beats of a period seem to belong to a single whole, is due to the continuity of the muscle sensations involved and the continuous feeling of slight tension between the positive and negative muscle sets; nowhere within the period does the feeling of strain die out.

But at the close of the period we have a pause which is demonstrably not a function of any of the intervals of the period. During this pause the tension between the two sets 'dies out,' and we have a feeling of finality. This gradual dying out of the tension is clearly seen in the constant appearance of the cone-shaped final syllable at the end of each nonsense verse.

The period composed of a number of unit groups (the verse, in nonsense syllables) has a general form which suggests strongly that it has

[1] *L. c.*, 447.

[2] For a determination and explanation of these peculiarities, such as the closer proximity of the unaccented to the accented beat in the iambic as contrasted with the trochaic foot, etc., *cf.*, Stetson, "A Motor Theory of Rhythm and Discrete Succession," *Psych. Rev.* 1905, *12*, 293 ff.

the unity of a single coördinated movement. There is no more reason for assuming a transcendental mental activity in the case of a rhythmic period than in the case of a single act which appears in consciousness as a unity..................................At some point in the period there is a definite climax, a chief accent; the movement 'rises' to that point and then falls off. This is strikingly seen in nonsense verses spoken with a heavy accent within the verse. The accent does not stand out from a dead level, but the verse culminates at that point.[1]

As a result of his previous study of perceived as opposed to produced rhythms and especially the effects of rhyme and of wide variations of tempo,—'lags,'—introduced into different portions of the verse and of the stanza, Stetson was led to the conclusion that

there is some definite process at the end of the verse which marks the close of the verse and which takes more time in the case of blank verse than in the case of rhymed verse. If we conceive the end of the verse as a point where a dying out of the tension occurs, we may imagine that the rhyme brings an emphasis, and becomes a qualitative signal for this release. The slight increase of intensity on the rhyme contributes to the breaking up of the coördination, and at the same time exhausts and satisfies the feeling of tension which the verse embodies........... A qualitative change may be supposed to produce the effect more rapidly than the simple dying out of the tensions, which occurs in blank verse without a differentiated end accent.[2]

This finality effect which rhyme augments is entirely analogous with the finality phenomenon in melody. We have seen that in three-tone sequences mere return to the original pitch may furnish the qualitative signal for the muscular 'resolution.' If the final tone is not merely a repetition of the initial tone, but has also the characteristics of a 'tonic,' the completion of the finality process is much more definitely assured. A third cause which sometimes operates to produce the same effect is the mere satisfaction of expectation. If one hears a certain irregular series of pitches, "related" or "unrelated," often enough so that the final tone can be recognized as such, one comes to feel that the group has a certain sort of

[1] *Rhythm and Rhyme*, 455.

[2] *L. c.* 425.

unity even though there is neither a return to a starting point nor an end on the tonic. The same holds true, to a certain extent, with reference to an unfamiliar succession of tones whose number is known in advance. If the observer is told to expect four tones, a motor disposition or attitude is established which constitutes a preparedness to react to four tones, and if only three tones are heard, the finality effect may fail to appear, although the third and final tone is at once a tonic and a return to the pitch of the initial tone of the sequence.

In each of these types of melodic finality, the closing tone institutes a response which is not wholly a new reaction but which is, on the contrary, the completion of an act already in progress. The feeling of finality arises only when the completion of the act issues in a muscular relaxation which is a dying out of balanced tensions. The facts regarding those finality effects which are due to the falling inflection also coincide with such a view. Rise in pitch is not merely a result of increased tension of the vocal apparatus: it likewise produces increased muscular tension in the hearer. A falling inflection at the close consequently serves to hasten the relaxation process which marks the completion of the melody.

Finally, a motor theory of melody makes possible an unambiguous statement of the nature of melodic "relationship." Two or more tones are felt to be "related" when there is community of organized response. "Unrelated" pitches fall apart because each demands its own separate attentive act of adjustment; but with "related" tones the attitude which appears as a response to the first is a preparation for the response to the second and is completed, not destroyed, by that response. The feeling of "relationship" is the feeling that arises when the tones elicit reactions which are in some measure common. When, on the other hand, the first tone calls up one set of associates and establishes a certain attitude or organization of incipient tendencies, while the second tone tends to call up a set of associates and establish an attitude which is at variance with the first, there can be no adequacy of coördinated response and the feeling of "relationship" is prevented from arising.

The origin of these well-articulated responses which generate the feelings of "relationship" is not to be sought in a single source. The operation of two main forces must be distinguished—one of them sensory, the other associative. The first of these, the phenomenon of consonance, is native and doubtless has its basis in the relatively simple action of the sensory apparatus in responding to auditory stimuli which are more or less similar—are, indeed, in a measure identical. But although the basis for consonance inheres in the inborn structure of the nervous system and the acoustical properties of vibrating bodies, nevertheless it is a commonplace of musical history and observation that these same native tendencies are subject to tremendous modification in the course of experience. One race, one age hears as consonant intervals which another age or race has never learned to tolerate; and within the history of individuals it is easily observable that consonance and dissonance are merely relative terms whose denotation shifts with growing experience. Moreover the whole complex group of phenomena we call tonality bears witness to the power of association to amplify and organize these native feelings.

But the associative factor or the factor of experience is directly efficient in determining what tones shall be felt as "related," quite apart from any effects which it has upon judgments of consonance. Mere custom, mere habituation to a certain succession of pitches results in a facility of recognition and response which is capable of generating these feelings of "relationship." The same kind of coördinated reaction is instituted and this makes possible the same resultant feeling as that brought about by response to two successive consonant tones. The "relationship" is in both instances traceable to the motor phase of the process.

The unity, then, which marks the difference between a mere succession of discrete tonal stimuli and a melody, arises not from the tones themselves: it is contributed by act of the listener. When tone follows tone in such a manner that the hearer can react adequately to each, when the response to the successive members of the series is not a series of separate

or conflicting acts but rather in each instance only a continuation or further elaboration of an act already going forward, then the tones are not felt as discrete, separate, independent, but as "related" to each other. And when, finally, the series of tones comes to such a close that what has been a continuous act of response is also brought to definite completion, the balanced muscular "resolution" gives rise to the feeling of finality, and the series is recognized as a unity, a whole, a melody.